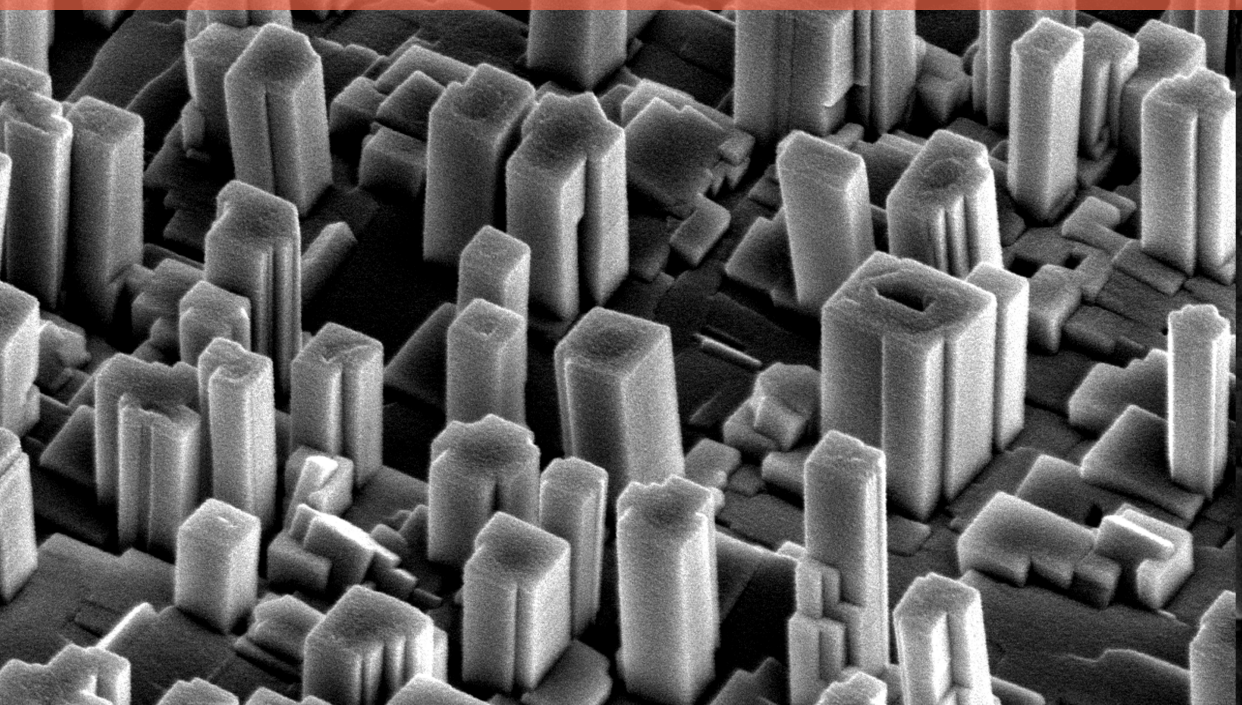
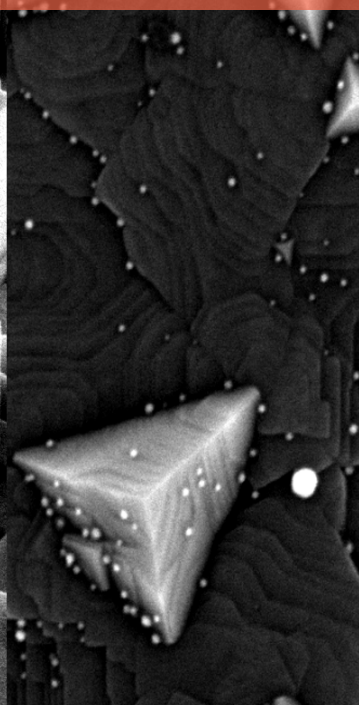
femto-st
SCIENCES &
TECHNOLOGIES

2023
ANNUAL REPORT





The FEMTO-ST institute is the largest public research laboratory in the Bourgogne-Franche-Comté region, located in eastern France, next to Switzerland and Germany. It comprises 7 scientific departments with approximately 750 staff members (PhD students, postdoctoral fellows, technicians, engineers, administrative staff, researchers and professors).

FEMTO-ST members are essentially employed by five different French public research organizations and higher education and research (HER) institutions: SUPMICROTECH-ENSMM (an engineering HER institution in microtechnologies and mechanics), University of Technology Belfort-Montbéliard in Energy (HER in mobility, networks and Industry 4.0), the University of Franche-Comté (a broad spectrum traditional university, which has celebrated in 2023 its 600th anniversary), the National Centre for Scientific Research (CNRS) and the University Bourgogne-Franche-Comté (UBFC, the federal HER institution in the region).

FEMTO-ST SCIENTIFIC MISSION

"Exploring Science and Innovation, from basic research to industries and spin-offs, from theory to experiments through high technology facilities, developing micro and nanotechnologies, increasing the density of functions and integrating intelligence for the engineering of components and systems with optimized performances, contributing to the future of a knowledge-based improved society."

FOREWORD

This year 2023 has a special flavour, as it is the end of the current mandate of the FEMTO-ST Executive Board. A new mandate is planned for January 2024, with a Board already appointed to continue the difficult task of managing a huge research institute such as FEMTO-ST. Each mandate cycle ends after an external evaluation of its activity, carried out by HCERES, the French evaluation agency for higher education and research institutions. I am particularly grateful and proud of the amazing work that has been done at the FEMTO-ST Institute over the last 7 years (2016-2022), and which has indeed been recognised as such by HCERES its 2023 evaluation report. Exceptional scientific contributions have been highlighted by the independent evaluation committee, pointing to a world-level positioning of the institute in many research topics, thus placing the institute among the best ones in France.

I wish that the reader of this 2023 FEMTO-ST Annual Report can gain more insight into what kind of amazing scientific work can actually be done by or with the talented researchers and staff at FEMTO-ST. I also wish that this report can trigger opportunities and ideas to develop new collaborative projects or attract new talents to join FEMTO-ST. Last but not least, I would like to thank all the members of FEMTO-ST for their commitment to our scientific mission, with a special mention to Professor Ausrine Bartasyte and Professor Fei Gao, both talented researchers and high quality deputy directors, who have efficiently and greatly helped me in managing and directing the institute activities over the past years.

Laurent Larger

Director of FEMTO-ST Institute

A BROAD RANGE OF MASTERED SCIENTIFIC EXPERTISE

FEMTO-ST INSTITUTE constists of 7 research departments and two transverse axes RECITS and BIOM'@X, which make collaborative efforts to organize multidisciplinary research activities. We also encourage multidisciplinary research activities in collaboration between departments.

APPLIED MECHANICS

- Materials, surfaces, processes, structures
- Micromechanics, microfabrication
- Fonctionalisation, smart structures
- Sustainability, reliability, biocompatibility

ROBOTICS & AUTOMATION (AS2M)

- Microrobotics, mechatronics
- Automation
- Prognostic & Health Management (PHM)

TIME & FREQUENCY (TF)

- Oscillators/ resonators
- Time & frequency metrology
- Microwave systems and sensors

COMPUTER SCIENCE (DISC)

- Parallel and distributed computing
- Formal methods for software engineering
- High performance computing
- Distributed smart microsystems

MICRO-NANOSCIENCES & SYSTEMS (MN2S)

- Opto-electro-mechanical microsystems
- Phononics and microscopy
- Nanosciences and nanostructured materials
- Biomicrosystems

OPTICS

- Nonlinear photonics
- Quantum photonics
- Nano-photonics
- Complex optoelectronic systems & AI

ENERGY

- Hydrogen-energy
- Electromagnetic converters
- Thermal machines
- Metrology and energy management

TRANSVERSE AXES

Biom'@x

- Towards technological translational medicine

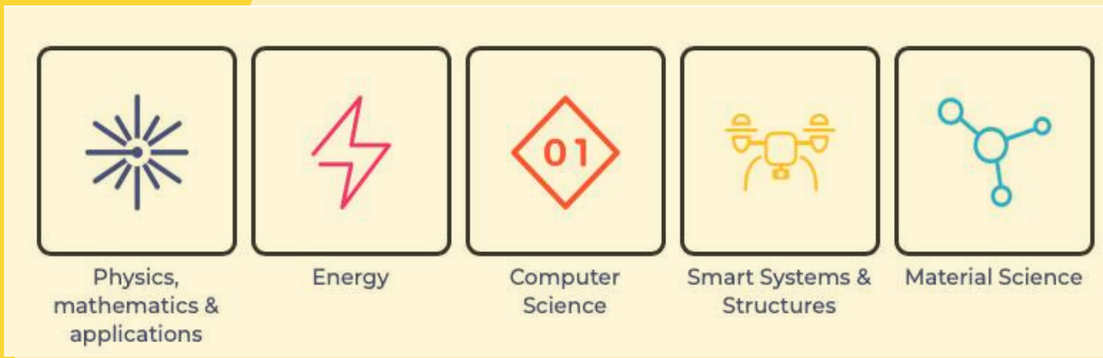
RECITS

- Research and study of industrial, technological and societal evolution

CONTENTS

EDUCATION

MASTER/PHD STUDIES IN FIVE RESEARCH AREAS



EIPHI-BFC
GRADUATE SCHOOL
CROSS DISCIPLINARY SCIENCE
AND TECHNOLOGY

EIPHI graduate school

at Bourgogne-Franche-Comté University
- 5 outstanding research areas
- Worldclass research labs
- Close connection with industry
- Broad mobility opportunities
- Tutoring and mentoring
- Scholarships

Coordinated by:
Hervé Maillotte (FEMTO-ST)
Gerard Colas des Francs (ICB)

https://gradschool.eiphi.ubfc.fr

frederic.peneau@ubfc.fr

GRADUATE SCHOOL EIPHI

The EIPHI Graduate School (GS) has now reached its 5th anniversary. In autumn 2023, a comprehensive mid-term report on the GS track record and impact will be submitted for evaluation by an international jury. The results of this evaluation, which will be known in early January, will determine whether the EIPHI dynamic will be continued for the next 5 years.

EIPHI, "Engineering and Innovation through Physical Sciences, High-technologies and cross-dIsciplinary research", is a training and research unit of the Bourgogne-Franche-Comté University (UBFC), selected at the end of 2017 by the PIA3 "Ecole Universitaire de Recherche" (EUR) programme. A joint initiative of the 3 CNRS research institutes (FEMTO-ST, ICB and IMB), EIPHI was built on the Labex ACTION (PIA1) excellence laboratory on "Smart systems embedded in matter", which was fully integrated into the GS thanks to its quite successful evaluation, but proposes a profound transformative evolution that characterises the goals and ambitions of the GS.

One of the recent very positive impact of EIPHI, is that it successfully attracted 4 other regional laboratories (ImViA, ICMUB, LmB, UTINAM), spreading its objective to intensify connections between Research, Education and Knowledge impact of Science into the society. EIPHI even contributed to help for the creation of 2 additional regional GS in 2 other fields of research, Health (INTHERAPI) and Agroecology (TRANSBIO).

FRANCE 2030

RÉGION BOURGOGNE FRANCHE COMTE

UBFC UNIVERSITÉ BOURGOGNE FRANCHE-COMTÉ

femto-st SCIENCES & TECHNOLOGIES

Institut UTINAM

ImViA

LmB

cnrs

icb

INSTITUT DE MATHÉMATIQUES DE BOURGOGNE

icmub Institut de Chimie Moléculaire UNIVERSITÉ DE BOURGOGNE

On the one hand, EIPHI adopts a broad and highly pluridisciplinary scientific approach, taking advantage of the recognised competences and numerous "niche" topics of international excellence of its 7 research institutes in the physical sciences and engineering, but also in the life sciences and social sciences and humanities. The GS has thus deliberately defined and nurtured a systemic, cross-disciplinary and societal-oriented scientific programme along 3 scientific axes:

- Adaptive Architectures, Advanced Materials & Processes;
- Monitoring & Prediction of Complex Systems;
- Active and Agile Compact Systems.

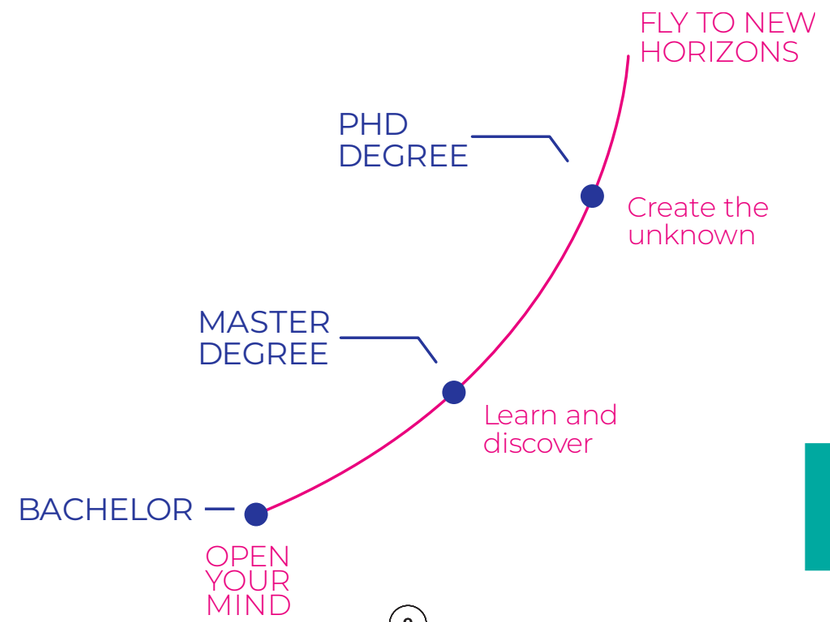
This programme optimally combines education, research & technology, innovation & industrial development and societal impact, with the main objectives of learning/training through research, structuring, pluridisciplinarity, addressing societal challenges and international impact.

On the other hand, a much deeper commitment is being made to education and training at graduate level in five areas covering mathematics, physics, chemistry and engineering, with an international ambition that is prompting a complete switch to English language teaching.

EIPHI thus aims to make a strong contribution to strengthening the academic excellence, visibility, readability and thus international attractiveness and ambition of the BFC Higher Education & Research (HER) landscape in the distinctive scientific area of "Advanced Materials, Waves & Smart Systems".

- **Promotion of the link between research and education,**
- **Continuity of the curriculum between Master and PhD degrees,**
- **Innovative pedagogy & international mobility,**
- **Professionalisation of graduate students.**

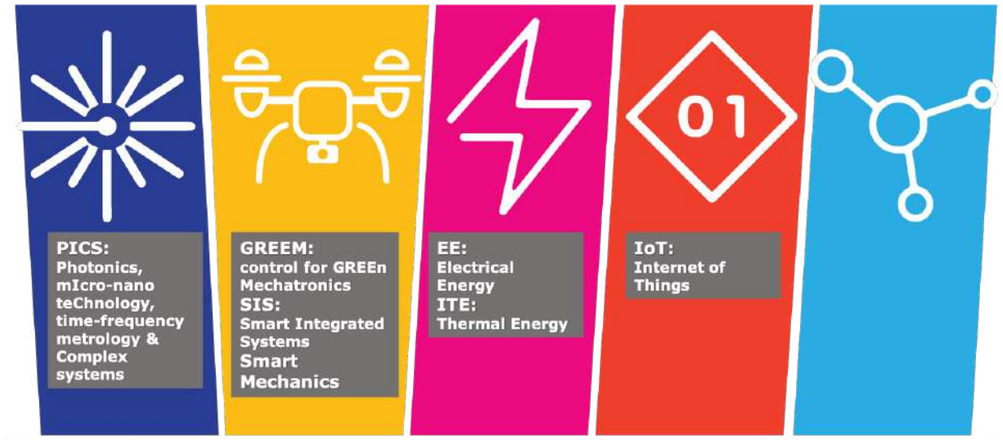
With the ambition to play a strong structuring and integrative role for the triptych of **research - education - innovation**, it has also been conceived to set goals and ambitions that are deliberately aligned with the industrial and socio-economic strategy of the BFC region, thereby contributing to strategic alliances and partnerships.



EIPHI-BFC
GRADUATE SCHOOL
CROSS DISCIPLINARY SCIENCE
AND TECHNOLOGY

Such a structuring ambition within the UFBC is based on 2 multidisciplinary universities (uFC, uB), 1 technology university (UTBM), 3 engineering schools (in Dijon and Le Creusot: ESIREM; in Besançon: SUPMICROTECH-ENSMM, ISIFC), complemented by a close partnership with the French CNRS as a national research organisation (NRO). EIPHI has also been designed to interact coherently with several other PIA initiatives: 2 training excellence projects, a national laboratory of excellence, an institute for technological research, 4 equipment of excellence, a company for accelerating technology transfer. Also, as another strong marker, the 3, then 7 research institutes that make up EIPHI host 9, then 13 other technological centres/platforms and a private R&D technological foundation (FC'INNOV), which represent an important asset for both graduate training, research, innovation and industrial cooperation within the GS. More recently, several additional PIA programmes (PIA3,4 and France 2030) have been funded within or around the EIPHI consortium (1 SFRI, 8 Equipex+, 1 CMA, 1 CMQ, 5 PEPR), which will further strengthen our structuring and excellence strategy. As a noteworthy feature that strengthens this overall strategy since 2021, EIPHI is now closely linked to and has been a prime mover of UBFC-InteGrate, another PIA3 SFRI programme that gathers EIPHI with 2 GS, TRANSBIO and INTHERAPI, respectively.

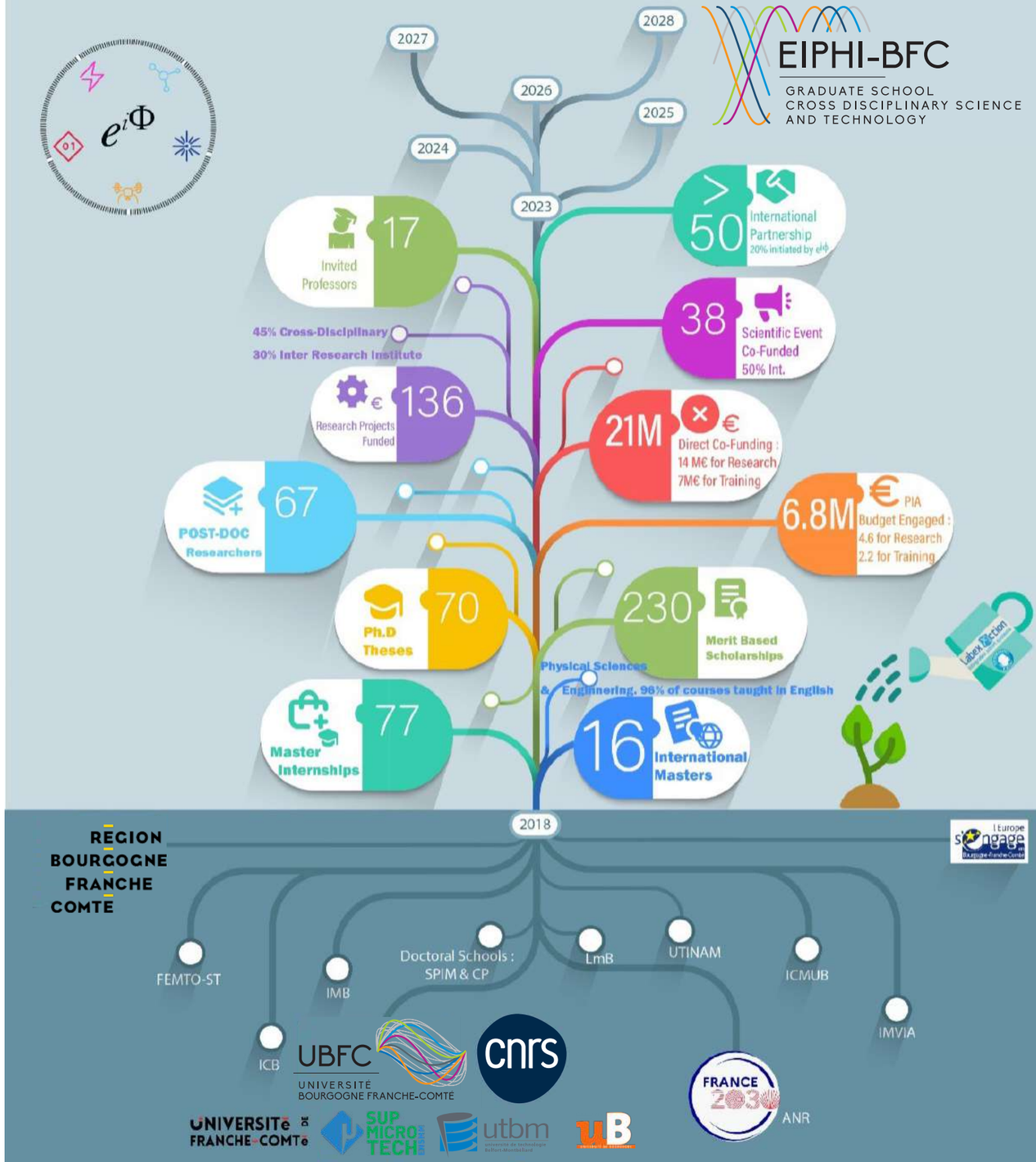
In order to resume the main task force directly implied, EIPHI has federated 3 world-renowned research institutes, FEMTO-ST, ICB, IMB (> 800 staff), while animating and promoting graduate degrees within the initial 9 and now 16 English Master tracks and 2 doctoral schools in 5 **domains: Physics, Mathematics & Applications; Energy; Informatics; Smart Systems & Structures; Materials & Chemical Sciences**. A major structuring step in 2021 was the integration of 4 other internationally renowned institutes (ICMUB, ImViA, UTINAM, LmB), enriching 3 of the 5 domains mentioned above with 5 additional international Masters, including an Erasmus Mundus Masters in Medical Imaging, while a second newly selected Erasmus Mundus in Quantum Technologies has started in 2022. At present, EIPHI unites a workforce of >700 research and training faculty members, 160 postdoctoral and research training contract staff, 395 support staff and >950 graduates (currently >530 PhD students and around 350 Masters students). This coverage represents 85% of the research and training workforce of the Bourgogne-Franche-Comté academic landscape in the UBFC strategic area of "Advanced materials, waves and intelligent systems".



EIPHI International Master degrees that are managed by FEMTO-ST

2018-2023

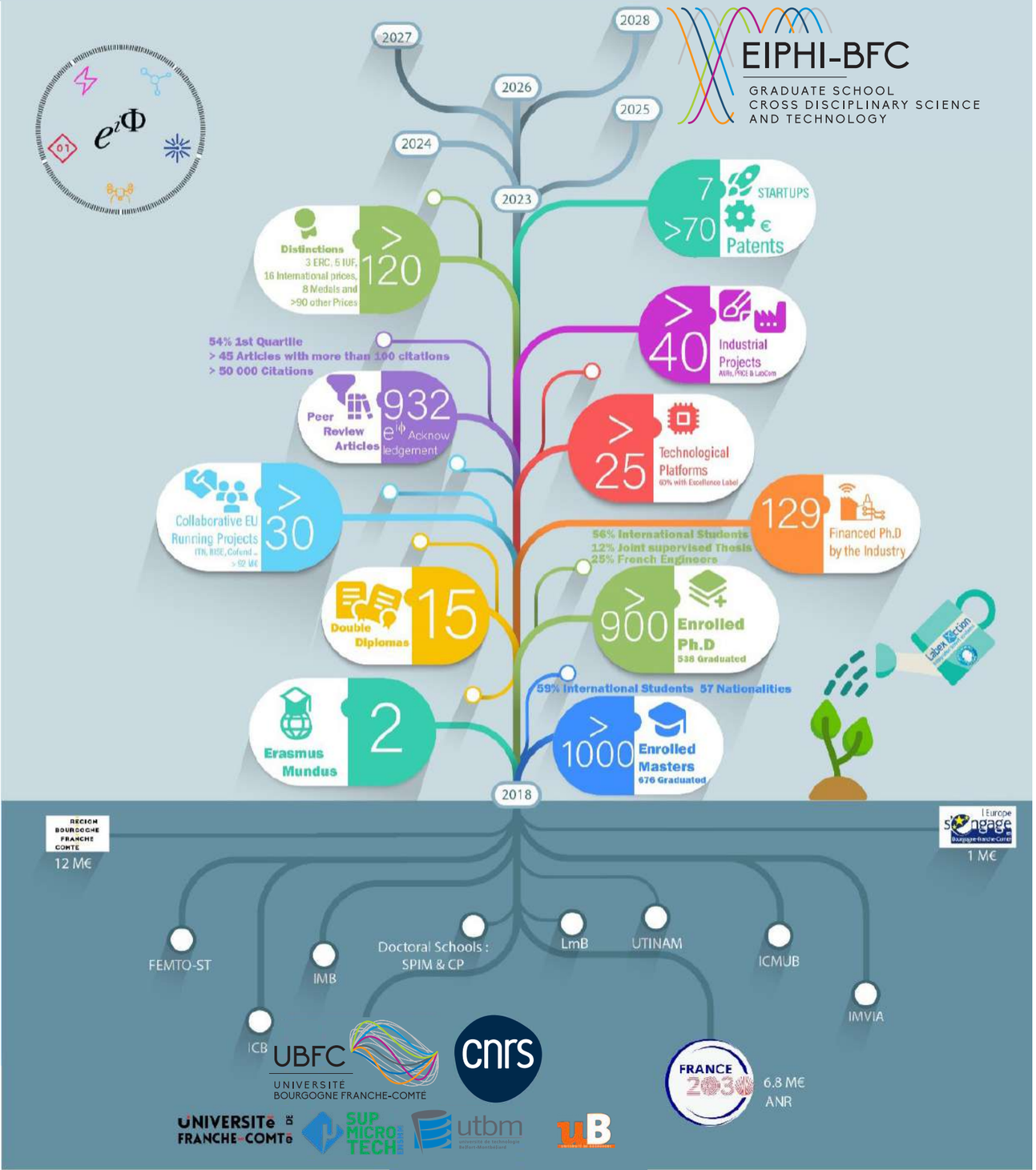
EIPHI Direct Contribution to the Research Training Link

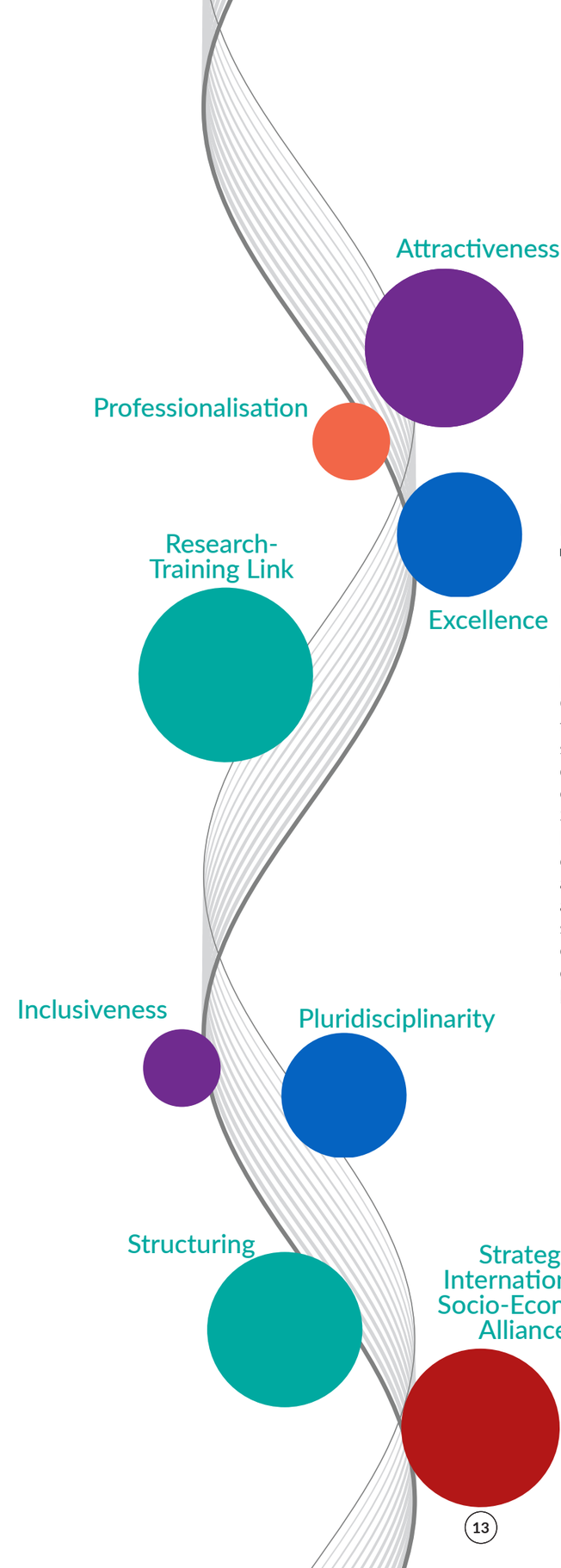


2018-2023

Highlights within EIPHI Ecosystem

7 Research Institutes, > 700 Researchers





Levers for Transformation

In short, the overall objective of the EIPHI Graduate School project is to create in the Bourgogne-Franche-Comté region a structured, coherent, interactive (cross-disciplinary), cohesive and efficient academic environment for research and teaching in the STEM fields (Science Technology Engineering Mathematics). This environment is intended to cover both the Master and PhD levels, in close association with an internationally recognised and networked research of excellence. EIPHI's strategy also aims to develop important concerns about the socio-economic impact of its academic activity, cultivating the links between science, society and the territory.

MSCA DOCTORAL TRAINING NETWORKS

LULLABYTE

Unraveling the Effects of Music on Sleep through Musicology, Neuroscience, Psychology and Computer Science

J.J. Aucouturier

AS2M

Project Lullabyte is an interdisciplinary project bridging musicology, neuroscience and computer science to investigate the effects of music on the sleeping brain. As an MSCA doctoral network, it funds 10 concurrent PhD positions in 10 partner laboratories in Europe (Germany, the Netherlands, Sweden, Denmark, France, Switzerland, Spain), as well as a series of joint projects (summer schools, hackathons, etc.) to strengthen collaboration between the 10 research teams. The project hosted by FEMTO-ST (Dept. AS2M, DATA-PHM team) investigates the use of control engineering methods (specifically system identification) to characterise how human neurophysiology (EEG) responds to continuous sound stimulation during sleep. By using engineering concepts and methods, we hope to provide innovative health technologies to improve and monitor sleep in both healthy subjects and patients with sleep disorders.

Consortium: Coord. Univ. Dresden (DE), Univ. Stuttgart (DE), Univ. Aarhus (DK), Radboud Univ. (NL), Institut Cerveau et Moelle Epinière (FR), FEMTO-ST (FR), Univ. Pompeu Fabra (ES), Royal Institute of Technology (SE), Univ. Fribourg (CH), Endel Sound GmbH (DE)

Total funding: 2.5 M€
FEMTO-ST funding: 250 k€

jean.aucouturier@femto-st.fr
https://lullabyte.de/

First bootcamp of the Lullabyte consortium organized in September 2023 at the Donders Institute for Cognitive Neuroscience, Radboud University, Nijmegen, The Netherlands.

ModConflex

Modelling and Control of Flexible Structures Interacting with Fluids

Y. Le Gorrec

AS2M

The network brings together 17 academic and industrial partners from across Europe with the aim of training the next generation of researchers in the modelling and control of flexible structures interacting with fluids, using and contributing to the latest advances in control theory, artificial intelligence and energy-based modelling. The concept of a flexible structure (or system) is used here in a broad sense as a complex system that can generate vibrations and includes wind turbines, floating platforms carrying wind and tidal turbines, flexible aircraft, electrical (micro)grids formed by wind turbines, soft robots and more. Key strengths of this consortium include a research environment that brings together mathematicians and engineers to provide a unique training environment for the project's young researchers, and a network of associated industrial partners that will allow all researchers to participate in industrial secondments.

Consortium: Coord. Friedrich-Alexander-Univ.Erlangen-Nürnberg (DE), Bergische Univ. Wuppertal (DE), Tel Aviv Univ. (IL), Univ. Twente (NL), UBFC-FEMTO-ST (FR), Univ. Bordeaux (FR)

Total funding: 2.8 M€
FEMTO-ST funding: 280 k€

yann.le.gorrec@ens2m.fr
https://modconflex.uni-wuppertal.de/

Kick-off meeting at the University of Twente, November 2023.

EUROPEAN TRAINING NETWORKS

Europe Horizon CleanH2

HyAcademy.EU

European Hydrogen Academy: to prepare for the future of the hydrogen revolution in Europe

F. Gao

ENERGY

The European Hydrogen Academy (HyAcademy.EU) is a pioneering initiative to support the emerging hydrogen sector in Europe. It focuses on the educational needs of the energy sector and addresses the projected demand for over one million skilled workers by 2030. The project involves a consortium of 15 partners, led by the University of Birmingham, with UTBM as the only French partner. HyAcademy.EU emphasises sustainable practices and industry-specific skills to shape the future of energy in Europe. This comprehensive educational pathway covers everything from basic knowledge in schools to advanced technological expertise and disruptive innovation at university level. The project, which involves more than 600 education and research institutions, will equip more than 5,000 future professionals and thousands of students with cutting-edge skills in the hydrogen industry. It includes the creation of an online portal for educational programmes and career opportunities in the hydrogen sector, with materials available in nine European languages. The aim is to create a self-sustaining platform that positions Europe at the forefront of hydrogen education and training at all levels.

Consortium:

Univ. Birmingham (UK)
Univ. Groningen (NL)
Politechnico de Torino (IT)
VSCHT (CZ)
Univ. Ploytech. Bucharest (RO)
Ulster Univ. (UK)
Univ. Modena and Reggio Emilia (IT)
Trakia Univ. (BG)
UTBM/ FEMTO-ST (FR)
Hydrogen Foundation of Aragon (ES)
DVGW (DE)
Bertz Associates (UK)
KIC Innoenergy (DE)
EUREC (BE)

FEMTO-ST funding: 226 k€

fei.gao@utbm.fr

Fei GAO - IEEE Industry Applications Society (IAS) Distinguished Lecturer

ENERGY

The IEEE Industry Applications Society (IAS) Distinguished Lecturer Programme is an important educational initiative that brings expert knowledge and cutting-edge research to a global audience. Through this programme, Distinguished Lecturers play a critical role in disseminating advances and innovations in electrical engineering and technology.

Fei Gao's contributions to this global programme focus on three key areas of modern electrical engineering:

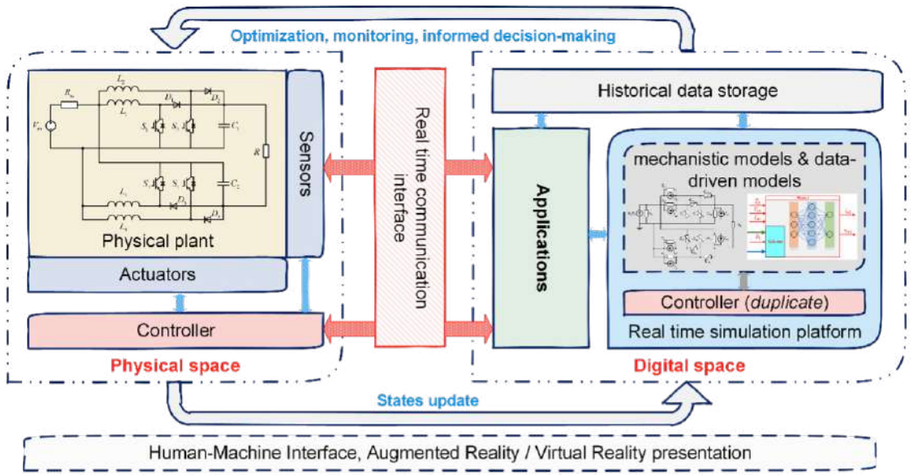
Fuel Cell Technology for Transportation Electrification: Prof. Gao's lectures provide a comprehensive overview of Proton Exchange Membrane (PEM) fuel cell technology, with an emphasis on its application in transportation. He will provide insights into the fundamental aspects of PEM fuel cells, their efficiency and supporting components, complemented by global examples and economic considerations.

Digital twin challenges for modern power electronic systems: In this talk, Prof Gao addresses the complexities and state-of-the-art solutions in real-time simulation and digital twin for power electronics. His discussions include detailed analyses of modelling approaches and hardware implementation platforms, providing a valuable perspective for professionals dealing with modern power electronic systems.

Hardware-in-the-loop (HIL) solver techniques for fuel cell models: Prof Gao also delves into the specialised field of real-time HIL applications for fuel cells. His lectures cover the intricacies of fuel cell model structures, focusing on accuracy, efficiency and stability in real-time simulations, bridging theoretical research with practical industrial applications.

https://ias.ieee.org/member-development/distinguished-lecturer-program/

fei.gao@utbm.fr



Digital twin structure for power electronics.

RESEARCH

THE SCIENTIFIC AXES OF FEMTO-ST INSTITUTE

Complex systems and information

fuel cell systems, thermal systems, systems and time-frequency metrology, health management prognosis, programmable matter, security and software testing, planning & scheduling, neuromorphic optical computing, embedded systems, distributed systems, artificial intelligence

Microsystems, micromechatronics

microrobotics, miniature microwave and optical atomic clocks, biochips, microfluidic circuits for health applications, integrated sensors, energy transducers, MEMS

Waves, complex matter and media of propagation

microacoustics, phononics and integrated photonics, nonlinear photonics and dynamics of optical pulses, laser beam shaping and fs laser-matter interactions, spatial or temporal manipulation of quantum states, atomic spectroscopy, vibro-acoustics

Advanced materials and processes

micro-/nano-fabrication, heterogeneous integration, metamaterials, electroactive materials ($LiNbO_3$), thin film growth, tribology, surfaces, molecular grafting on the surface, 3D-4D structuring, fs laser machining, composites and architectural materials, bio- and eco-materials, precision machining, micromechanics

AWARDS

AGATHE FIGAROL

Associate Professor

UFC

MN2S

Agathe Figarol obtained her PhD in 2014 from the Ecole des Mines de St-Etienne for her work on the toxicity of carbon nanotubes. After a year as a regulatory toxicologist, she worked as a postdoctoral researcher first at Paul Sabatier University on nanomedicine, then at Osaka University on tissue engineering of brain microvasculature. In 2020, she was a temporary lecturer at the Jean Lamour Institute and the Nancy Faculty of Pharmacy. Since 2021, she is an associate professor at the University of Franche-Comté, teaching at the ISIFC and developing her research project in the MN2S department of FEMTO-ST Institute, within the BIND team.

agathe.figarol@femto-st.fr

https://www.proanima.fr/ethicscience/3d-glimpse-une-tumeur-sur-puce-pour-combattre-le-glioblastome/

Descroix-Vernier Ethic-Science Prize, Innovation Category: new concepts & technology transfer

Every two years since 2013, the Pro Anima Scientific Committee, associated with the Fondation Descroix-Vernier from 2022, selects research programmes using high-quality alternatives to animal models for the study and understanding of human pathologies, for the development of therapeutics or for the assessment of the toxicity of molecules consumed by humans.

Glioblastoma is the most common and aggressive form of brain cancer, with a survival rate of less than 18 months. New therapeutic approaches are hampered by the inadequacy of preclinical models. As an alternative to overly simplistic in vitro models or animal experiments with ethical burdens and uncertainties related to inter-species differences, the 3D-Glimpse project is developing a vascularised tumour-on-a-chip. In a microfluidic device, human cells can be organised in 3D in a hydrogel to form a tumour microenvironment with capillaries perfused to mimic blood flow. Biosensors will help to study the transport and efficiency of innovative nanomedicines to better understand and treat brain tumours.

BLONDEL MEDAL 2023 by Society for Electricity, Electronics, Information and Communication Technologies

The Blondel Medal is awarded each year to a French or foreign academic or industrial scientist for outstanding work that contributes to the advancement of science and the electrical and electronics industries in the broadest sense, and that is carried out with the same thoroughness and rigour that characterised André Blondel's work.

This medal recognises the critical contributions of her work on the resilience of fuel cell and hydrogen systems. In particular, her research interests include increasing the performance, reliability and durability of hydrogen systems (fuel cells and electrolysers) while decreasing their costs, through combination of experimentation, physics based models and artificial intelligence.

The final aim is to develop resilient, smart and self healing hybrid systems including other power sources where non invasive, low cost monitoring, and robust control for safety, reliability and durability is integrated.

NADIA YOUSFI STEINER

Full Professor

UFC

ENERGY

Nadia YOUSFI STEINER received Master's degrees in Mathematics and in Fluidics and Energetics in 2006, her Ph.D. in Engineering Science in 2009, and from 2009 to 2014 she worked as an R&D project manager in charge of collaborative projects on hydrogen and fuel cells at the European Institute for Energy Research in Karlsruhe, Germany. She has held a 6-year research Chair of Excellence at the FEMTO-ST Institute within the Energy Department in Belfort, France, before becoming Full Professor at the University of Franche-Comté. She was recently awarded the CNRS bronze medal for her research. She is heavily involved in education (Master of Engineering Hydrogen Energy, CMI H3E, awarded the "Trophée des Hydrogenies" in 2021) and outreach activities on hydrogen technologies (Hyckatlon, etc.).

nadia.steiner@femto-st.fr

Award "Cristal Collectif 2023" by CNRS

The "Cristal Collectif" award recognises teams of men and women, research support staff, who have carried out projects that are particularly remarkable for their technical mastery, collective dimension, applications, innovation and impact..

JEAN-CLAUDE JEANNOT

Technical Director

CNRS

MIMENTO

jcjeannot@femto-st.fr

https://projets.renatech.org/

Jean-Claude Jeannot, Technical Director of MIMENTO clean room, has been awarded a Cristal Collectif 2023 Award, along with 10 other research support staff from the Renatech network, for his work in developing "REPOTECH".

Repotech is the web application used to manage the projects of the various micro-nanotechnology facilities of the Renatech+ network of the CNRS. Since its launch in 2022, Repotech has allowed the management of more than 2400 projects with more than 3600 users, providing simplified access to project highlights and statistics on the use of Renatech facilities.

This collaborative work highlights the strength of the Renatech network, which not only provides access to state-of-the-art micro-nanotechnology equipment, but also seeks to jointly develop procedures and tools for the efficient management of technological facilities.

Cristal Collectif 2023 Award ceremony at IEMN on 12/12/2023 in the presence of L. Buchaillot the director of CNRS Engineering Institute (J.-C. Jeannot can be seen on the right side of the stage.).

RECOGNITIONS

IEEE Fellow & IEEE IAS Distinguished Lecturer

IEEE Fellow is a prestigious honour conferred by the Institute of Electrical and Electronics Engineers to recognize members with extraordinary accomplishments in IEEE fields of interest. Less than 0.1% of members achieve this status, symbolizing exceptional achievements in research, development, education, and leadership in technology and engineering disciplines.

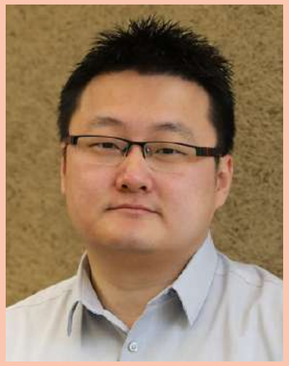
Prof. Fei Gao's research has significantly advanced both digital twin technology for energy systems and AI-enhanced powertrain control in hybrid electric scooters. His key contributions include developing advanced real-time simulation techniques for power electronic devices using Field Programmable Gate Arrays (FPGA) with sub-microsecond resolution, essential for the design and testing of electrified vehicle powertrains. In the realm of hybrid scooters, his work in applying AI for powertrain control significantly enhances the efficiency and longevity of hydrogen electric energy sources, marking a major advancement in hybrid light-duty scooter technology.

FEI GAO

Full Professor

UTBM

ENERGY



Prof. Fei Gao, Full Professor at UTBM, specializes in hydrogen fuel cells and digital twin technology. he received the PhD from UTBM in 2010 with the Youth Doctor Award. He is an IEEE and IET Fellow, authoring over 200 publications, including 2 books and 6 chapters. Prof. Gao earned accolades like the 2020 IEEE J. David Irwin Early Career Award, 2022 Leon-Nicolas Brillouin Award, and 2022 Sustainable Future Visionary Award. He's a Distinguished Lecturer for IEEE, Editor-in-Chief of IEEE Industrial Electronics Technology News, Deputy Editor-in-Chief of IEEE Transactions on Transportation Electrification, and holds leadership roles in various IEEE committees.

fei.gao@utbm.fr

International Fellow of the Chinese Optical Society

The Chinese Optical Society is a nongovernmental organization bringing together workers in the field of optics and engineering. It has extensive international linkages and is a member of the International Commission for Optics (ICO). The distinction of International Fellow recognizes major achievements in optics and is the society's highest honour.

John Dudley has made a wide range of contributions to ultrafast and nonlinear optics, particularly in the fields of broadband supercontinuum source development and the study of nonlinear instabilities. He is also committed to education and the public communication of science, and since 2018, he has worked with UNESCO and other international bodies in the frame of the International Day of Light which is a permanent and annual United Nations observance celebrating optical science and its applications. This celebration has seen over 2500 events take place in more than 100 countries, as well as global awareness-raising campaigns reaching millions worldwide.

JOHN M. DUDLEY

Full Professor

UFC

OPTICS

John Dudley received B.Sc and Ph.D. degrees from the University of Auckland, New Zealand in 1987 and 1992 respectively. In 1992 and 1993, he carried out postdoctoral research at the University of St Andrews in Scotland before taking a lecturing position in 1994 at the University of Auckland. In 2000, he was appointed Professor at the University of Franche-Comté in Besançon, France. He currently serves in the post of Chargé de Mission (Special Advisor) on Science Communication at the University of Franche-Comté.

john.dudley@univ-fcomte.fr
https://members.femto-st.fr/john-dudley/en

MARIE-ANGE MANIER

Full Professor

UTBM

DISC

Marie-Ange Manier obtained her engineering degree in 1990 from the ENSMM (National School of Mechanics and Microtechnology, France). She obtained her PhD in Computer Science and Automation from the University of Franche-Comté in 1994. She is currently a full professor at the Belfort-Montbéliard University of Technology (UTBM). From 2014 to 2017, she was the director of a UTBM research unit called OPERA (Optimisation and Networks). Since 2018, she has been working in Optimisation and Operational Research at the FEMTO-ST Institute. In particular, she leads the scientific axis "Planning and Scheduling" within the DISC/OMNI team of FEMTO-ST.

marie-ange.manierl@utbm.fr

Certificate of Recognition from SAGIP

This certificate of recognition was presented during the SAGIP Congress in 2023 in Marseille. SAGIP is the Society of Automation, Industrial Engineering and Productics, which represents IFAC (International Federation of Automatic Control) in France, in coordination with the GDR MACS of the CNRS.

Marie-Ange Manier was recognized for her significant contribution and her influence in the fields of Automatics, Industrial Engineering and Productics in France and internationally. Her research interests focus on the development of models and algorithms based on operations research to solve combinatorial optimisation problems. This includes the design, planning and scheduling of discrete event systems with applications to industrial and logistic systems (manufacturing and services), such as workshop scheduling with transport resources, vehicle routing problems, public transport planning, hydrogen supply chain network design, port logistics... Her contributions range, for example, from the creation and exploitation of new disjunctive graphs to the solution of original variants of combinatorial optimisation problems, including the proposal of a new notation to identify and classify specific scheduling instances.

THIBAUT SYLVESTRE

Research Director

CNRS

OPTICS

With a PhD in engineering, Thibaut Sylvestre is a dedicated researcher specialising in nonlinear optics. He graduated from the University of Franche-Comté and completed his post-doctoral studies at the ULB, Belgium. Since 2001, he has been a full-time researcher at the CNRS, FEMTO-ST Research Institute, focusing on passively mode-locked fibre lasers and Raman amplification for telecommunications. In 2012, he was awarded the Fabry de Gramont Prize for his contributions to nonlinear photonics. He is an active member of prestigious societies such as the Optical Society of America, the IEEE Society and the French Society of Optics.

thibaut.sylvestre@femto-st.fr
https://members.femto-st.fr/thibaut-sylvestre/en

OPTICA Fellow 2024

Optica Fellows are selected on the basis of outstanding contributions to research, business, education, engineering and service to Optica and the optics community. Yearly elected Fellows cannot exceed 0.5% of the current total membership and the election process is highly competitive. Candidates are recommended by the Fellow Members Committee and approved by the Awards Council and the Board of Directors.

Thibaut Sylvestre leads theoretical and experimental studies of fundamental nonlinear optical phenomena with the aim of investigating potential applications in telecommunications, lasers and fibre sensors. He was nominated for his pioneering contributions to optical fibre and laser research and technology.

STUDENT AWARDS

Grand Prize in the iPhD 2023 Innovation Competition

The national i-PhD competition is organized by the Ministry of Higher Education, Research and Innovation in partnership with Bpifrance. This competition is reserved for young doctors or PhD students who wish to create or co-create a Deeptech start-up via innovation technology transfer promoting research results.

JULIEN DUFOURMANTELLE

PhD at FEMTO-ST (2020), ICE fellowship (Itinéraire Chercheur-Entrepreneur, BFC region), start-up creation @ DECA-BFC incubator

MN2S

The cheese industry needs to monitor the cheese manufacturing process. As the properties of the milk change every day, the cheesemaker must adapt to measure the parameters of the milk coagulation stage linked to cheese technology. The main goal is to increase the yield of production, stabilize the cheese quality directly on the production line and ultimately optimize the coagulation stage. This research project is about designing an acoustic sensor to monitor the milk coagulation process in real time directly in the tank. The sensor enables measurement of viscoelastic properties. This project is being led in collaboration with INRAE, ACTALIA, ENIL, and CNIEL.

julien.dufourmantelle@gmail.com

jfmanceau@femto-st.fr, vincent.humblot@femto-st.fr

2nd Prize at the Science Spark E-Poster Presentation

PUZZLE X: The Leading Global Event for Frontier Tech | Future (Barcelona)

FANNY PELISSON

PhD student

APPLIED MECHANICS

A comprehensive review of dynamic fibre property characterisation revealed limited information on individual plant fibre damping. This research developed methods for individual fibre extraction, matrix embedding, vibration tests and finite element modelling to address this knowledge gap. Vibration tests captured damping and storage moduli, showcasing specific fibre behaviours. Environmental impacts and structural limitations were identified, prompting refined models and environmental controls. Future prospects include exploring composite fibre damping, interphase analysis, utilising nanoindentation and Brillouin spectroscopy techniques. This approach aims to enhance understanding and effectiveness in composite design whilst refining individual fibre characterisation for optimal composite development.

fanny.pelisson@femto-st.fr
https://www.puzzlex.io/

Biot-Fourier Prize

French Society of Thermal Engineering

Annual award to PhD students or early career researchers

JULIEN PETITGIRARD

PhD at FEMTO-ST & Stellantis (2022)

ENERGY

In this study, we have proposed to add the phenomena of transfer by radiation in a reduced nodal model. This nodal model makes it possible to identify the temperatures of electrical wires in a bundle. To achieve this, we have a purely conductive nodal model and propose a method to identify radiation conductances based on geometric subdivision: the Laguerre tessellation. Finally, we integrate these conductances into the previous model and present a study of the influence of the phenomenon of transfer by radiation.

J. Petitgirard, P. Baucour, D. Chamagne, E. Fouillien and J.C. Delmare, SFT 2023, https://doi.org/10.25855/SFT2023-092

https://youtu.be/hdVYMkFLgmo?si=bbsI6O8224RNUXe5

philippe.baucour@univ-fcomte.fr

Graduate Assistantships in Developing Countries (GRAID)

International Mathematical Union, Commission for Developing Countries (IMU/DC)

The highly selective programme (31 PhD theses in 6 years) supports the most talented students from developing countries to study full-time for a PhD in mathematics. Students receive a monthly stipend and additional support by linking their research with an internationally recognised mathematician.

KARIM SANKARA

PhD student

OPTICS

Karim Sankara is a Burkinabé doctoral student co-supervised by C. Maire (Optics, FEMTO-ST) who is enrolled in a PhD programme at the University of Nazi Boni in Bobo-Dioulasso, Burkina Faso. In the spring of 2023, Karim spent 3 months at FEMTO-ST, supported by the EIPHI Graduate School (additional stays are scheduled). Karim's work is in arithmetic and is part of the inverse Galois program, with imposed local and global conditions. The topic involves algebra, arithmetic, group theory, and analytic number theory.

https://www.mathunion.org/cdc

karim.sankara@univ-fcomte.fr

STUDENT AWARDS

Two Best Student Paper Awards

Conference EuroCVD-Baltic ALD, major international conference in the field of CVD (Leuven)
Summer school of the CNRS network (GdR) ELNANO "Elaboration of nanomaterials for the recovery, conversion, transport and storage of energy" (Aussois)

ISHAMOL LABBAVEETTIL BASHEER
PhD student

TIME & FREQUENCY

$KNbO_3$ has exceptional piezoelectric and electro-optic properties, but it is not available in the form of large crystals. Thin film growth is also far from routine due to major challenges related to difficulties in controlling the volatile K_2O composition in the films, poor physical properties of the grown films and their irreproducibility. Chemical deposition methods allow easier control of volatile components than physical deposition methods. However, reliable K precursors for CVD are not commercially available. Ishamol has demonstrated controlled K composition in $KNbO_3$ films using advanced metal-organic precursors (synthesised by collaborators at the University of Catania). This enabled the growth of high quality epitaxial $KNbO_3$ films with good ferroelectric properties. This opens up new possibilities for the development of new generation electro-active devices in the fields of micro-acoustics, electro-optics, actuators, sensors, etc.

ishamol.labbaveetti@femto-st.fr

2nd Prize for Best Presentation

Conference on New Technologies for Computer and Robot Assisted Surgery (Paris)

CHIBUNDO JOSHUA NWAFOR
PhD student

AS2M

A miniaturised continuum robot is a type of robotic system that consists of a flexible, slender body that can perform complex 3D motions in a continuous manner. The robot's motion is achieved by deformation of its body, rather than by the use of rigid links connected by joints. The concept is to exploit the micro-scale flexibility of glass to design miniaturised continuum robots for potential biomedical applications. We have demonstrated the miniaturisation of continuum robots made of glass considering two kinematics of interest: the concentric tube robot (CTR) and the parallel continuum robot (PCR).

C. Nwafor et al., IEEE/ASME Transactions on Mechatronics (2023), https/doi.org/10.1109/TMECH.2023.3276230 & Advanced Intelligent Systems 5(2), 2200308 (2023), https://doi.org/10.1002/aisy.202200308

chibundo.nwafor@femto-st.fr

PhD Thesis Award

MSH (Human Science Center) federation of Bourgogne Franche-Comté

PhD Thesis Award for interdisciplinary research in human and social science (HSS)

NASTASYA WINCKEL
PhD student

RECITS

After interdisciplinary research on territorial dynamics (ORTEP project), her current work focuses on the economic impact of energy transition in non-interconnected islands. Her research uses general computable equilibrium (GCE) models to understand how hydrogen applications will affect macroeconomic aggregates in islands (HyLES project). In parallel, she continues cross-disciplinary research, in particular between HSS and engineering on energy scenario forecasting. The MSH Prize was awarded for the results of her PhD thesis. The first PhD objective was to help coin the concept of territorial revitalisation with researchers from other social sciences. The dissertation was also an opportunity to study cross-disciplinary processes from the perspective of participant observation. An important contribution is the adaptation of the concept of territorial revitalisation to the specific case of old industrial areas. Finally, the results presented are also empirical and operational, since they tested the concept on two industrial areas, Belfort and Montbéliard, and drew up several guidelines for local actors.

M. Gasnier, N. Winckel et al., Cybergeo: European Journal of Geography 0 46 (2022). https://journals.openedition.org/cybergeo/38404

nastasya.winckel@utbm.fr

Thesis Award of the CNRS Robotics Group (GdR)

Journées Nationales de la Recherche en Robotique (Moliets)
Selected for 36 scientific national highlights of CNRS (2022)

MAXENCE LEVEZIEL
PhD student

AS2M

During his PhD, Maxence Leveziel developed a miniature robot, MiGriBot, capable of manipulating micrometric objects at unprecedented speeds. This work was published in the prestigious journal Science Robotics in 2022. MiGriBot is a miniature robot capable of manipulating objects as small as 40 micrometers with cycles of up to 720 pick-and-place operations per minute, with sub-micron repeatability. This performance makes it the world's fastest pick-and-place robot on any scale.

M. Leveziel et al., Science Robotics, 7(69), eabn4292 (2022). https://doi.org/10.1126/scirobotics.abn4292

redwan.dahmouche@femto-st.fr

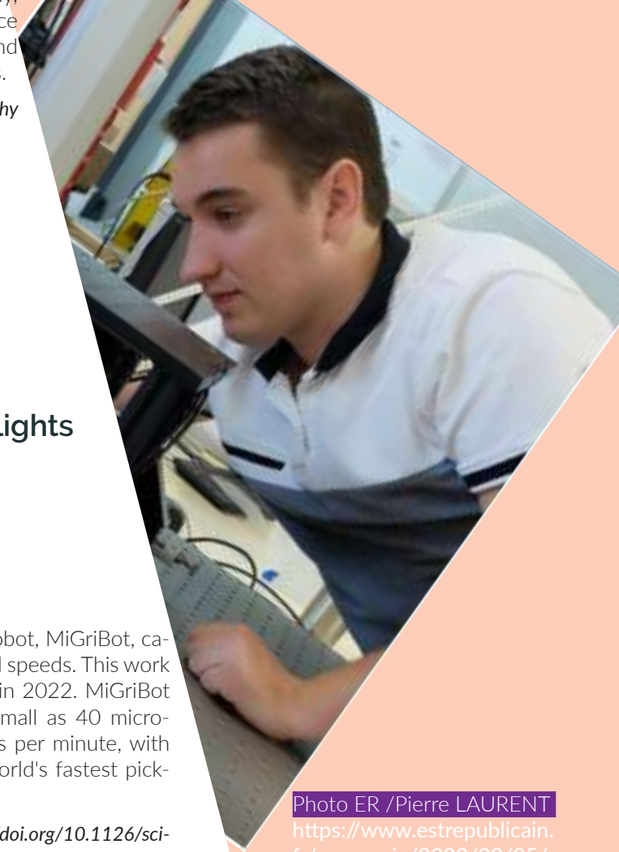


Photo ER /Pierre LAURENT
https://www.estrepublicain.fr/economie/2022/09/05/bon-courage-a-ceux-qui-voudraient-nous-copier

STUDENT AWARDS

Best Student Poster Award

Summer school of the 9th Symposium on Frequency Standards and Metrology

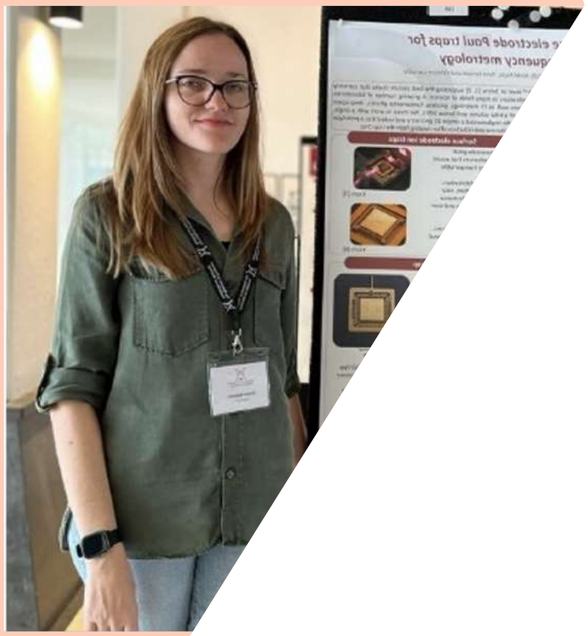
MARTINA MATUSKO
PhD student

TIME & FREQUENCY

During her PhD, Martina developed expertise in several disciplines. She has worked on projects such as ultra-stable frequency propagation over fibre, which has enhanced her knowledge of digital electronics, fibre optics, phase noise cancellation and frequency stability. In addition, her direct involvement in the Active Superradiant Optical Atomic Clock project has broadened her knowledge of atomic physics and quantum optics, particularly in specialised areas such as laser spectroscopy and the cooling and trapping of atoms.

M. Matusko et al., Rev. Sci. Instrum. 94 (3), 034716 (2023), https://doi.org/10.1063/5.0138599

martina.matusko@femto-st.fr



Best Student Poster Award

9th Symposium on Frequency Standards and Metrology

JOSIPA MADUNIC
PhD student

TIME & FREQUENCY

In the frame of her PhD, Josipa Madunic works on a single-ion optical clock based on a surface electrode trap, which is commonly used in quantum information. Her main focus has been on the design and implementation of a high-voltage resonator for the ion trap, as well as on the electrical characterisation of the trap itself. In addition, she is actively involved in laser stabilisation using well-established methods such as saturated absorption. Her work will also extend to delivering an ultra-stable laser signal for clock operation.

josipa.madunic@femto-st.fr

Best Student Paper Award

Frontiers in Ultrafast Optics Best Student Paper Competition – Photonics West 2023

VALERIA BELLONI
PhD student

OPTICS

Bessel beams are quasi-nondiffracting beams that find numerous applications, for example, in high-aspect ratio laser material processing. The interaction between the hollow cylindrical core of a high order Bessel beam with sapphire generates extreme conditions. The high pressure causes the translation of a rod of material outside the bulk of silicon. Nano-pillars with high aspect-ratio can be generated with a single laser pulse. They are featured by a sub-micron diameter and height exceeding 10 µm. The main benefits of this nano-fabrication approach are its speed, absence of pre- or post-processing, and that it does not require clean-room facility.

valeria.belloni@femto-st.fr

NEW MEMBERS

DORINE TABARY

AssociateProfessor
UFC

DISC

Quantum analysis using formal calculation tools in the context of symplectic geometry

dorine.tabary@univ-fcomte.fr
https://dorine34.github.io/WebSite/

From 2021 to 2023, she was an ATER at the University of Franche-Comté and a member of the Vesontio team. From 2019 to 2021, she did a PhD at IRIMAS (Institut de Recherche en Informatique, Mathématiques, Automatique et Signal). In 2018, she was an intern at LIRMM (Montpellier Computer Science, Robotics and Microelectronics Laboratory).

ISMAEL JECKER

Associate Professor
UFC

DISC

Automata theory and game theory, with a particular focus on the application of these fields to automatic program synthesis

ismael.jecker@femto-st.fr
https://ismaeljecker.github.io/

He obtained his PhD degree in Computer Science from the Université Libre de Bruxelles. He was a postdoc at the Institute of Science and Technology Austria and at the University of Warsaw. His research focuses on the automata-theoretic approach to formal methods, delving into abstract objects to address real-world challenges and to extend the range of abstract machines for which model checking and synthesis algorithms exist, while identifying and mitigating the theoretical complexities in these algorithms.

JEROME DEJEU

Associate Professor
SUPMICROTECH-ENSMM

MN2S

Surface modification, biomimetic surfaces, biomolecular interactions, kinetics and affinity constants, optical methods such as surface plasmon resonance and interferometry.

jerome.dejeu@femto-st.fr
www.femto-st.fr/fr/personnel-femto/jeromedejeu2

He obtained PhD degree in Chemistry-Physics in 2007 on the growth and stability mechanisms of polymer multilayers. He then carried out a postdoctoral research in FEMTO-ST Institute (AS2M) on the functionalisation of grippers or surfaces to control their super-adhesive, conductive or anti-adhesive properties. In 2012, he was recruited as an associate professor at the University of Grenoble Alpes to study biomolecular interactions.

REMI MEYER

Research Engineer
UFC

TF & OPTICS

ultrafast lasers (femto- & picosecond pulses, frequency combs...), spatial beam shaping, optical instrumentation, non-linear physics, and time-frequency metrology

remi.meyer@femto-st.fr
https://remimeyer.fr

He defended his PhD thesis on ultrafast laser-plasma interactions at FEMTO-ST in 2020 (Optics). After 9 months of local postdoc, he decided to turn to art. For the last three years, he has worked as a photographer promoting science for public institutions (UBFC, CNRS, INRAP...) and as a scientific illustrator (for journal publications, ERC/ANR proposals...). He has also carried out research on the shaping of supercontinuum beams for artistic purposes.

THOMAS JEANNIN

Associate Professor
UFC

APPLIED MECHANICS

Mechanical and numerical characterisation of the behaviour of bio-based composites, eco-design of microsystems

thomas.jeannin@femto-st.fr

He obtained his PhD degree in 2016 at Applied Mechanics Department of FEMTO-ST Institute. His thesis focused on the tribology of cutting press tools in tungsten carbide in order to reduce their wear. Then, he did a Postdoctoral research on the mechanical behaviour of bio-based composites.

NANCY AWAD

Associate Professor
UFC

DISC

Bio-inspired algorithms for self-reconfigurable modular robots for tasks such as locomotion, camouflage, and interacting

nancy.awad@univ-fcomte.fr

She started PhD research in computer science on privacy at the FEMTO-ST Institute in 2016. After finishing her PhD, she broadened her research skills through two postdoctoral positions at Orange Labs (France) and INSA-CVL (France), working on privacy violations and challenges in anonymised data. In terms of teaching, she started as a part-time lecturer at Antonine University (Lebanon) during her PhD, followed by two ATER positions at IUT Belfort-Montbéliard and INSA - Centre Val de Loire (France).

LAURENT NOTE

PAST (Associated Staff on Temporary Duty)
UFC/ISIFC

MN2S

Support to regulatory monitoring development of risk analysis tools, industrial relationship

laurent.note@univ-fcomte.fr

An independent consultant for more than 30 years, Laurent Note is an ENSMM engineer with a degree in business administration. He works with industrial companies in the management of quality, safety and environmental risks. As a temporary associate at the ISIFC (engineering school of the University of Franche-Comté), he manages Biotika®, a training module set up in the form of a university design office.

FLORIAN BOUCHERIE

General Secretary
CNRS

Direction

florian.boucherie@femto-st.fr

Responsible for monitoring European research policies at CLORA, he joined FEMTO-ST in 2017 as European project manager (SSUCHY, S3-4AlpClusters). He became at the same time project manager of the Labex ACTION before becoming deputy manager of the EIPHI graduate school.

General Secretary of FEMTO-ST since 2021, he is a member of the Executive Committee and head of the financial and administrative service.

RESEARCH HIGHLIGHTS

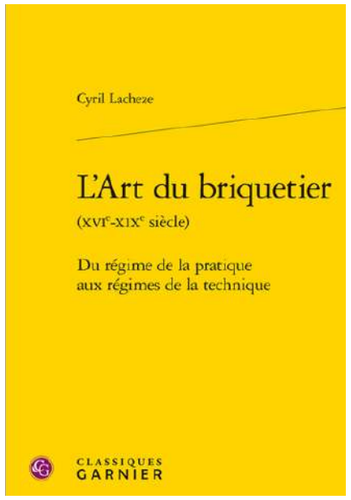
Book "L'art du briquetier, XVIe-XIXe siècle. Du régime de la pratique aux régimes de la technique"

C. Lacheze, in a collection edited by M. Gasnier
within Classiques Garnier editions.

RECITS

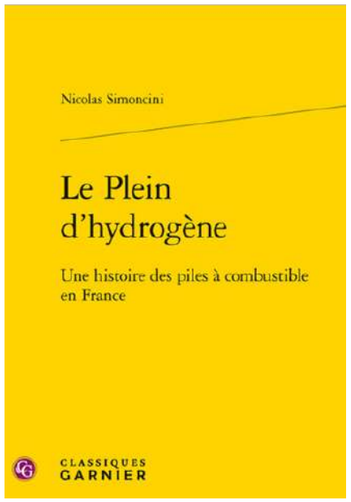
This book is the publication of a PhD thesis defended in 2020. It aims to explore the different perceptions of the same technology by different social actors and the interactions between these perceptions, a topic that has not yet been widely explored in the field of history of techniques. The case study is the production of architectural terracotta (bricks, tiles, etc.) between the 16th and 19th centuries in France, where practical know-how, technological development and encyclopaedic writing or advertising came together. This book also provides an up-to-date overview of a subject that has received little attention in recent decades.

From a methodological point of view, the large corpus - manuscript, printed, iconographic, archaeological sources - is examined from a systemic perspective: taking into account all the actors in society and their interrelationships, avoiding the use of preconceived analytical schemes in order to fully grasp the complexity of the system. The result is a set of interaction logics that can be found throughout the system, beyond any particular context. Again, this is a relative novelty, since the value of such an approach has been emphasised in the field of humanities for some thirty years, but has rarely been implemented effectively, precisely because of its extreme complexity and the amount of work required to take account of all the interrelationships. This book is therefore intended as a 'proof of concept' and provides methodological guidelines for replicating such an analysis on other topics.



Paris, Classiques Garnier (coll. Histoire des techniques), 2023, 1043 p., https://doi.org/10.48611/isbn.978-2-406-14694-0

cyril.lacheze@utbm.fr



Paris, Editions Classiques Garnier, 2023, https://doi.org/10.48611/isbn.978-2-406-15114-2

Book "Le Plein d'hydrogène. Une histoire des piles à combustible en France"

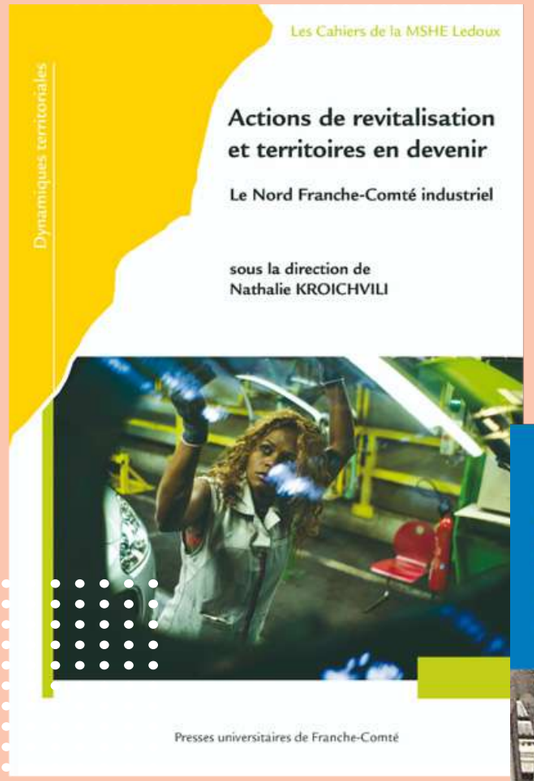
N. Simoncini

RECITS, ENERGY

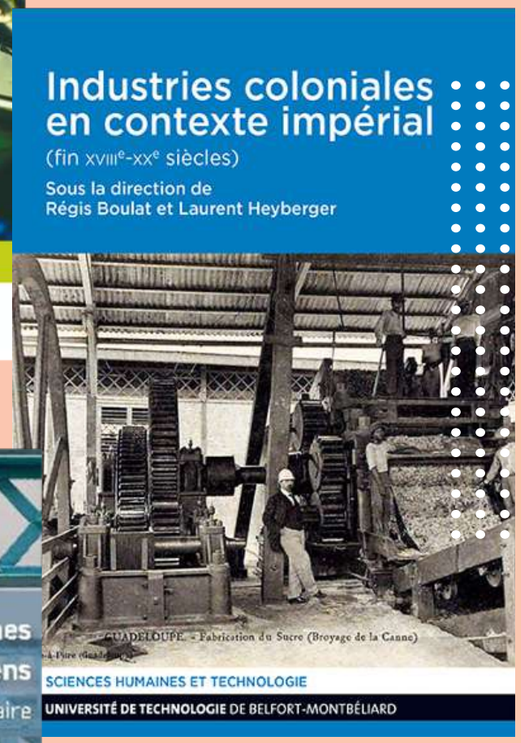
The book retraces the history of fuel cells in France, from the discovery of their operating principle at the Académie des Sciences in 1838 to the development of the hydrogen plan by the government in 2020. One section is devoted to the beginnings of research in Belfort nearly 25 years ago. It also lays the foundations for a design approach to hydrogen technologies that is guided by concern for the milieu.

https://classiques-garnier.com/le-plein-d-hydrogene-une-histoire-des-piles-a-combustible-en-france.html

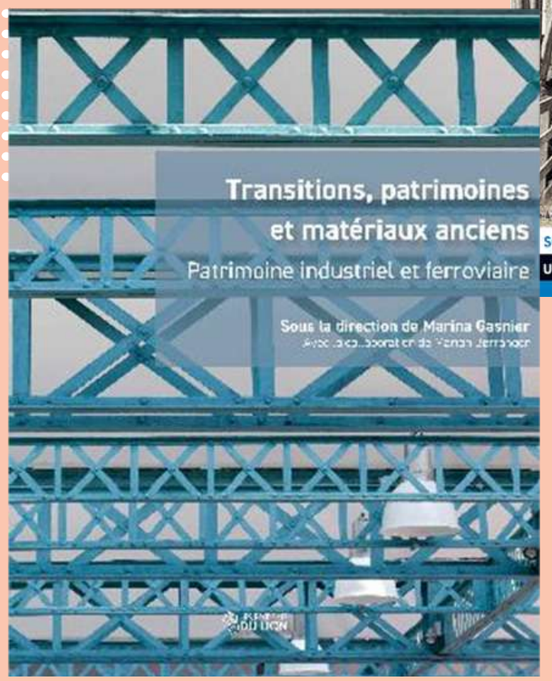
nicolas.simoncini@utbm.fr



Presses universitaires de Franche-Comté
Edited by Nathalie Kroichvili (RECITS)



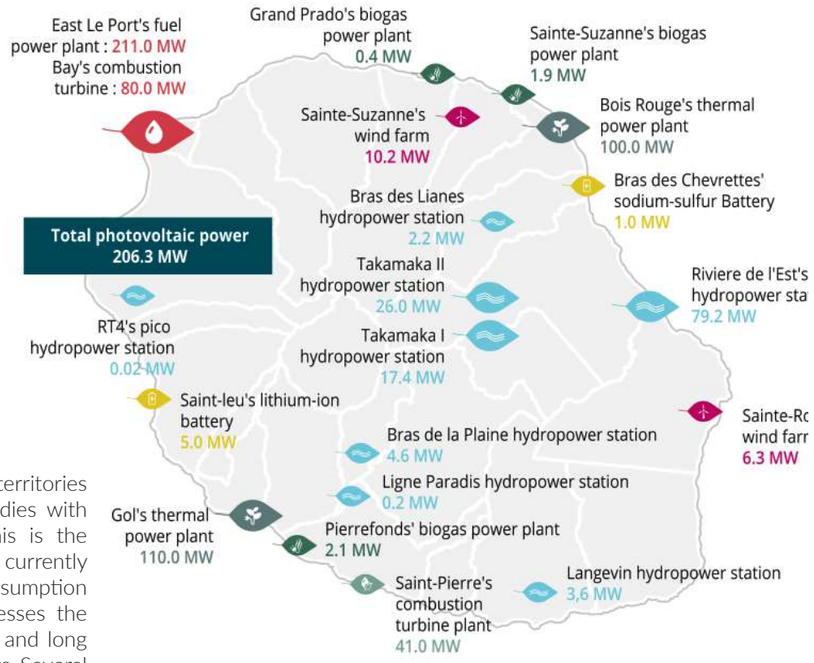
Pôle éditorial de l'UTBM
(collection Sciences humaines et technologie)
Edited by Régis Boulat et Laurent Heyberger (RECITS)



Les éditions du Lion
Edited by Marina Gasnier et Marion Berranger (RECITS)

RESEARCH HIGHLIGHTS

Assessment of Medium and Long Term Scenarios for the Electrical Autonomy in Island Territories: The Reunion Island Case Study



A. François, R. Roche

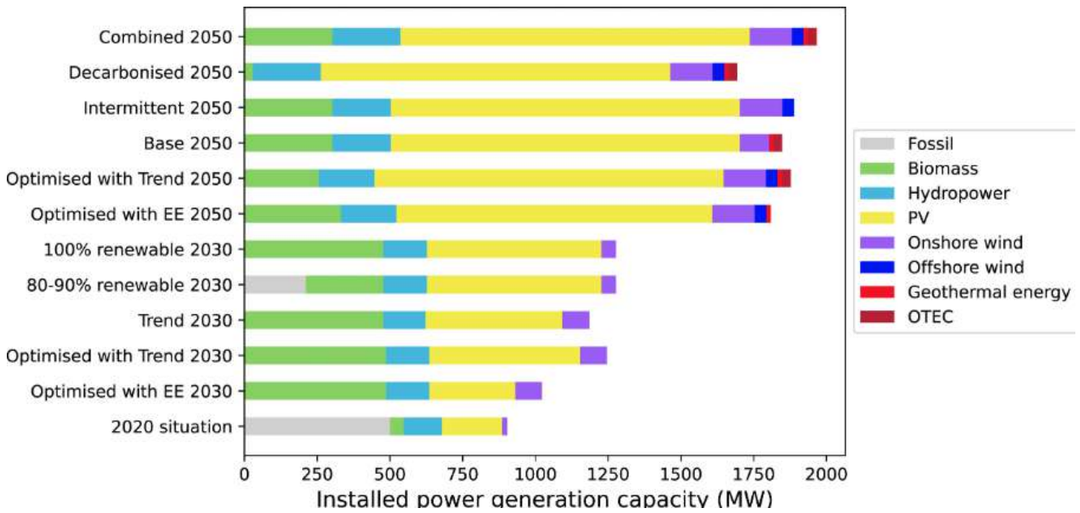
ENERGY

Due to their specific energy context, island territories are at the forefront of energy transition studies with the aim of achieving energy autonomy. This is the case of Réunion, where the electricity mix is currently 70% carbon-based and 80% of energy consumption is imported. In this context, this article assesses the infrastructures to be installed in the medium and long term in order to gradually reduce energy imports. Several scenarios of installed electricity generation capacity for the years 2030 and 2050 are studied, combined with two scenarios of electricity consumption. Simulations are carried out according to these scenarios in order to define the electricity mix and the investments in new batteries and in the reinforcement of the electricity transmission network. For 2030, the results show that a reduction in consumption compared to the trend could reduce costs and environmental impacts. For 2050, investment in new electricity generation technologies is essential to meet the needs of a 100% electrified vehicle fleet. If overall consumption does not follow an energy demand management plan, all energy sources on the island will need to be maximised. The energy transition will also require large storage facilities and little reinforcement of the current high-voltage electricity network.

A. François et al., Renewable Energy 216, 119093 (2023), ISSN 0960-1481, https://doi.org/10.1016/j.renene.2023.119093

https://projects.femto-st.fr/hyles

robin.roche@femto-st.fr



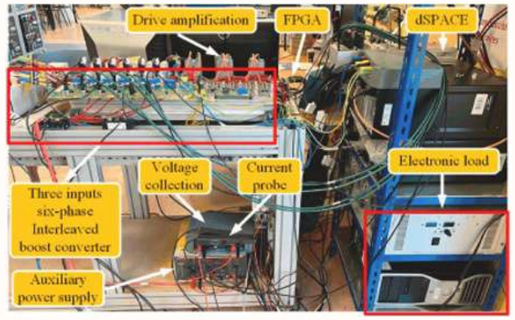
Installed capacities (MW) for the 2030 and 2050 scenarios.

Multiple Inputs Multi-phase Interleaved Boost Converter for Fuel Cell System Applications

X. Hao, I. Salhi, S. Laghrouche, Y. Ait Amirat, A. Djerdir

ENERGY

Hydrogen as a clean energy source has been attracting attention and support due to the fact that it only produces water, heat and unreacted gas after combustion. Considering the requirements of commercial applications in terms of fuel cell (FC) durability and the costly aftercare of a high power FC with performance degradation, multiple fuel cell (MFC) systems are proposed to address the above issues. In addition, the structure of MFCs can well handle the problems of lack of redundancy and further improve the output power of the whole system. Due to the non-linear current-voltage characteristic of the FC, converters are usually used as indispensable components to obtain a constant DC voltage. The following requirements should be considered for converters used in FC applications: (a) FC current ripple reduction; (b) voltage boost function; (c) redundancy design; (d) volume and weight requirements. A test bench was set up to validate the correctness of the proposed converter under the different experimental conditions. The main contributions of this work are as follows:



- A three-input six-phase interleaved boost converter is designed for fuel cell systems;
- The designed converter shows high scalability and good fault tolerant capability;
- A solution is proposed for the implementation of six PWM signals in dSPACE1104;
- Experimental verification of the designed converter with different fuel cell systems;
- Load disturbance rejection, variable reference voltage and FC failure are validated.

X. Hao et al., IEEE Trans. Power Electron. (2023), https://doi.org/10.1109/TPEL.2022.3149099

X. Hao et al., Int. J. Hydrogen Energy, 46 (78), 38827 (2021).

N. Marx et al., Int. J. Hydrogen Energy, 39 (23), 12101 (2014).

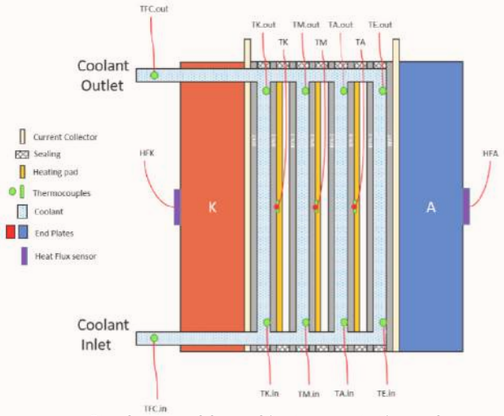
youcef.ait-amirat@univ-fcomte.fr

A New Cooling Circuit and its Control Strategies for the Thermal Management of PEMFC in Rapid Startup Application

S. Bégot, V. Lepiller, W.H Saidouni

ENERGY

This study presents an experimental investigation of a new liquid cooling circuit and its control strategies. The aim is to meet the thermal management requirements of a proton exchange membrane fuel cell during startup. The cooling circuit creates an alternating flow through the stack. Cell heat generation is achieved by inserting heating pads, allowing the study of heat transfer behaviour independent of the electrochemical reaction. New circuit control strategies are compared with reference strategies for no flow circulation or unidirectional flow. The duty cycle of the alternate flow is adjustable, and the stages where the fluid is at rest in the fuel cell can be included. We show that this new cooling system can provide a temperature rise of 26 °C in 85 s. A maximum temperature difference between the top and bottom of the cells of 1 °C and 3 °C along the stack is observed.



Stack assembly and instrumentation scheme .

S. Bégot et al., Int. J. Hydrogen Energy (2023). https://doi.org/10.1016/j.ijhydene.2022.12.166

https://www.femto-st.fr/fr/personnel-femto/sylviebegot

sylvie.begot@univ-fcomte.fr

RESEARCH HIGHLIGHTS

A Review on the Proton-Exchange Membrane Fuel Cell Break-in Physical Principles, Activation Procedures, and Characterization Methods

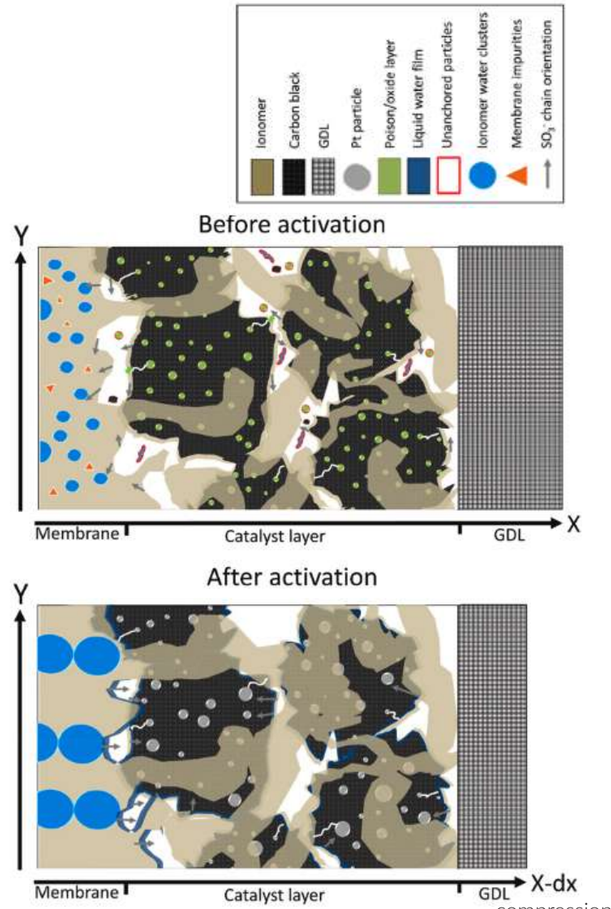
D. Bouquain, E. Pahon

ENERGY

The Proton Exchange Membrane Fuel Cell (PEMFC) is an emission-free alternative to the internal combustion engine. Post-assembly, a PEMFC must be "activated', to elevate and stabilize its performance to a reproducible threshold value. This process is costly, time consuming and not suitable for mass production. This paper provides a detailed review of the physical principles of break-in, activation procedures and characterisation methods. First, all the sparse knowledge from the literature is translated into a set of activation mechanisms. Activation of a cell mainly changes the morphology of the membrane electrode assembly (e.g. catalyst layer porosity, catalyst size, shape and activity, polymer chain orientation). Second, an in-depth analysis off all break-in methods is provided. Cell components can be pre-activated using steam, acid, plasma or compression. Dynamic, high temperature/pressure and supersaturated operation promote break-in kinetics. Generation of oxidising and reducing conditions is essential and can be achieved by short circuiting, cyclic voltammetry, cathode starvation or reactant switching. Uniform activation over the cell surface is achieved by gas flow reversal or hydrogen pumping. Compression cycles minimise PEMFC contact resistance. Finally, the shortcomings of conventional break-in characterisation methods (to measure cell performance and impact on durability) are highlighted. Better reproducibility is achieved using advanced electrochemical characterisation, post-mortem and cell output species analysis.

F. Van der Linden et al., Journal of Power Sources 575, 233168 (2023), https://doi.org/10.1016/j.jpowsour.2023.233168

david.bouquain@univ-fcomte.fr



Morphological changes endured by the MEA during break-in.

Wind Tunnel Measurements of Dynamic Aerodynamic Coefficients Using a Freely Rotating Test Bench

L. Muller, Y. Bailly, J.-C. Roy

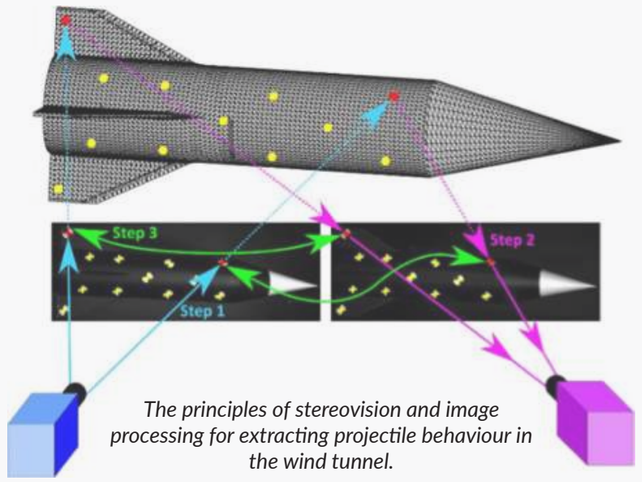
ENERGY

The purpose of this paper is to develop a dedicated measurement methodology capable of simultaneously determining the stability and pitch damping coefficient in a wind tunnel using a single and almost non-intrusive metrological setup called MiRo. In order to assess the reliability, repeatability and accuracy of the MiRo method, measurements obtained with this technique are compared with other sources such as aerodynamic balance measurements, alternative wind tunnel measurements, Ludwieg tube measurements, free flight measurements and computational fluid dynamics (CFD) simulations. Two different numerical approaches are compared and used to validate the MiRo method. The first numerical approach forces the projectile to describe a pure oscillatory motion with small amplitude along the pitch axis during a rectilinear flight, while the second numerical approach couples the one-degree-of-freedom simulation motion equations with CFD methods.

MiRo, a novel and almost non-intrusive technique for dynamic wind tunnel measurements, was validated by comparison with five other experimental and numerical methods. Despite two completely different approaches, both numerical methods give almost identical results and show that the holding system has almost no effect on the dynamic aerodynamic coefficients. It can therefore be concluded that the attitude of the MiRo model in the wind tunnel is very close to that in free flight. The MiRo method allows the attitude of a projectile to be studied in a wind tunnel with the least possible impact on the flow around a model.

L. Muller et al., International Journal of Numerical, Methods for Heat & Fluid Flow 33 (4), 1562 (2023), https://doi.org/10.1108/HFF-09-2022-0548

yannick.bailly@univ-fcomte.fr



The principles of stereovision and image processing for extracting projectile behaviour in the wind tunnel.

Elsevier Academic Press
Authors:
H. Bai, C. Liu, D. Majstorovic, F. Gao (Energy)

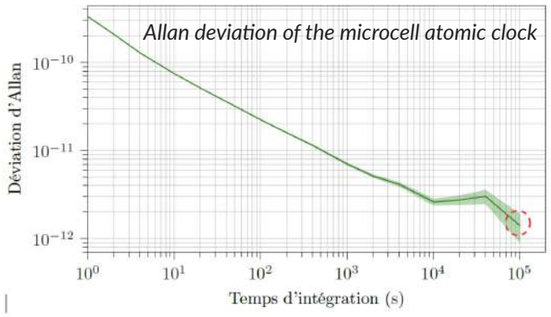
RESEARCH HIGHLIGHTS

Microcell Based Atomic Clock with Frequency Stability in the Low 10^{-12} Range at 1 Day

C. Carlé, M. Abdel Hafiz, S. Keshavarzi,
R. Vicarini, N. Passilly, R. Boudot

MN2S, TIME & FREQUENCY

The long-term frequency stability of miniature atomic clocks is often degraded by light-shift effects and a possible evolution of the microcell inner atmosphere. In a recent study, the sensitivity of the clock frequency to variations of the light field was mitigated by more than 2 orders of magnitude through the use of an advanced pulsed interrogation protocol. In addition, the variations of the Ne buffer gas pressure in the cell have been drastically reduced through the use of a micro-fabricated cell built with low permeation alumino-silicate glass (ASG) windows. Combining these approaches, a microwave microcell-based clock with a fractional frequency stability of 1.4 × 10^{-12} at 10^5 s was measured (about 100 ns/day). This stability level at one day is competitive with the best current microwave vapor cell atomic clocks.



C. Carlé et al., Optics Express 31, 5, 8160-8169 (2023). https://doi.org/10.1364/OE.483039

rodolphe.boudot@femto-st.fr
nicolas.passilly@femto-st.fr

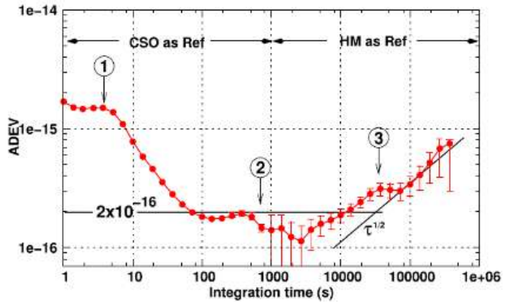

Photograph of cryogenic sapphire oscillator

New Stability Record for Cryogenic Sapphire Oscillators

C. Fluhr, B. Dubois, F. Vernotte,
E. Rubiola, and V. Giordano

TIME & FREQUENCY

We have reported in Applied Physics Letters the outstanding frequency stability performances of an autonomous cryogenic sapphire oscillator (CSO) presenting a flicker frequency noise floor below 2×10^{-16} near 1, 000 s of integration time and a long term Allan Deviation (ADEV) limited by a random walk process of around 1×10^{-18} $\sqrt{\tau}$. The frequency stability qualification at this level required the implementation of sophisticated instrumentation associated with ultra-stable frequency references. This result is technologically sound as it demonstrates the potentiality of the CSO technology from which a fully operational system has been developed and commercialised by our R&D center FEMTO Engineering. From the physical point of view, it sets an upper limit to the ultimate noise floor of the cryogenic microwave resonator that is competitive with that of the ultra-stable optical Fabry-Pérot cavities.



Allan deviation of cryogenic sapphire oscillator

C. Fluhr et al., Appl. Phys. Lett., 123, 044107 (2023). https://doi.org/10.1063/5.0153711

giordano@femto-st.fr

A Submillimeter Diameter Glass Concentric Tube Robot with High Curvature

C.J. Nwafor, G.J. Laurent, P. Rougeot,
K. Rabenorosoa

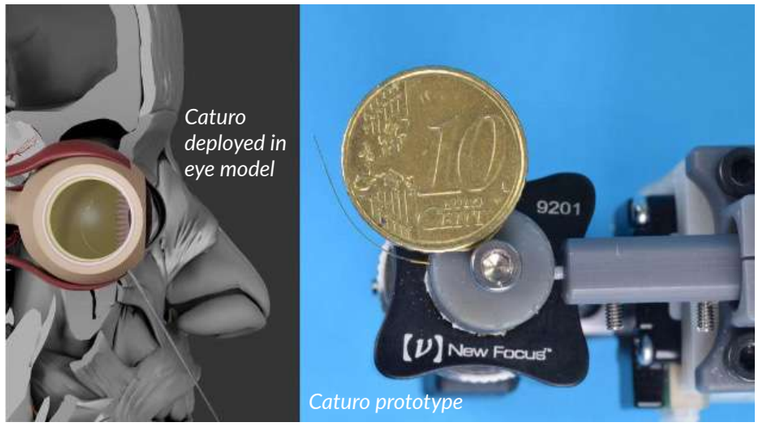
AS2M

A key need in medicine is further miniaturisation of dexterous miniaturised devices for microsurgery. Developing robots and instruments that are compact and flexible makes them safer and easier to manoeuvre in delicate biological environments. To this end, ROMOCO team at AS2M department has built the smallest concentric tube robot to date, which they have named Caturo. Most CTRs are currently made of nitinol because of its super-elastic properties and biocompatibility. Here, glass-polymer composite tubes are proposed to facilitate shape setting, reduce friction and benefit linear elasticity. Caturo also has an unprecedented radius of curvature of up to 5 mm. It is manufactured by heat treating a thin heat-shrinkable polymer tube on a glass capillary in a 3D printed mould. The fabrication process is fast, versatile and relatively inexpensive. Various free-space deployment operations are demonstrated, such as 3D helical precurved tube deployment, conical-spiral deployment, and constrained 3D deployment through needle orifices. Finally, precurved optical fibre deployment with laser emission capability, fluid sample aspiration, delivery operation, and visualisation under optical coherence tomography (OCT) are proposed.

C.J. Nwafor et al., Advanced Intelligent Systems, 5(2), 2200308 (December 2022), https://doi.org/10.1002/aisy.202200308

https://www.femto-st.fr/fr/Departements-de-recherche/AS2M/Equipes-de-recherche/ROMOCO

kanty.rabenorosoa@femto-st.fr



Caturo prototype

RESEARCH HIGHLIGHTS

Miniaturized Bloch Surface Wave Platform on a Multicore Fiber

C. Eustache, V. Karakhanyan, M. Suarez, R. Salut, T. Grosjean

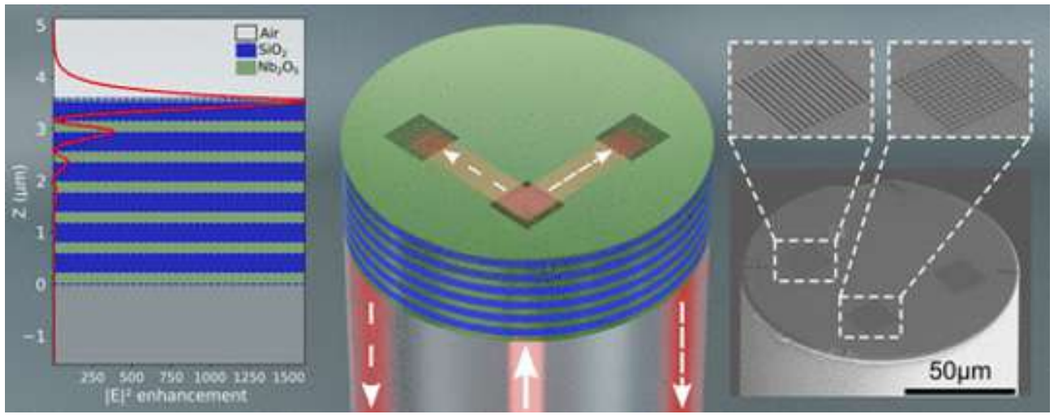
OPTICS

The need for novel tools able to sense and analyze environmental parameters within tiny recesses is seen to rapidly grow in many scientific, medical and industrial domains. Being compact, robust and flexible, optical fibers are widely considered a promising optical tool for addressing this demand. The integration of micro or nano-optical structures, such as ring micro-resonators, photonic crystals, metasurfaces, onto fiber tips can further improve specific optical functionalities for imaging, analyzing and controlling physical, chemical and biological quantities on a very local scale. In counterpart, optical fibers offer the opportunity to export nano-optics out of the lab for in-situ or in-vivo applications in a wide field of research, industrial and medical domains.

We proposed a novel implementation of a miniaturized photonic platform fabricated on a multicore fiber tip, capable of tunable optical functions via coupling to Bloch surface waves (BSWs). A one-dimensional photonic crystal is deposited on the cleaved surface of a fiber tip, allowing the propagation of BSWs in the near-infrared. On top of each core, subwavelength gratings are fabricated to operate as optical couplers between BSWs and the corresponding fiber modes. The ability to control the optical interconnection among different pairs of cores of the multicore fiber via polarization-selective BSW coupling is demonstrated. The resulting compact, tunable, and portable platforms can be fruitfully employed in the vast application domain covered by optical fiber technology including sensing, optical trapping, manipulation, and information processing.

C. Eustache et al., ACS Photonics 10 (6), 1694 (2023). https://doi.org/10.1021/acsphotonics.2c01011

thierry.grosjean@univ-fcomte.fr



Left: schematic diagram of the multilayer stack sustaining Bloch surface waves (intensity profile in red). Middle: Artistic view of an on-tip nano-optical platform based on Bloch surface waves for interconnecting three cores of multicore fiber. Right: SEM image of a corresponding fiber-integrated micro-platform.

Nanophotonics Special issue 'Neural network learning with photonics and for photonic circuit design'

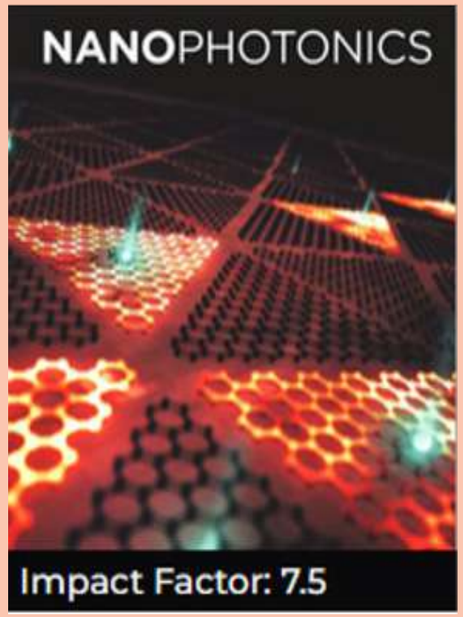
Editors: D. Brunner (FEMTO-ST), M.C. Soriano (IFISC), S. Fan (Stanford)

OPTICS

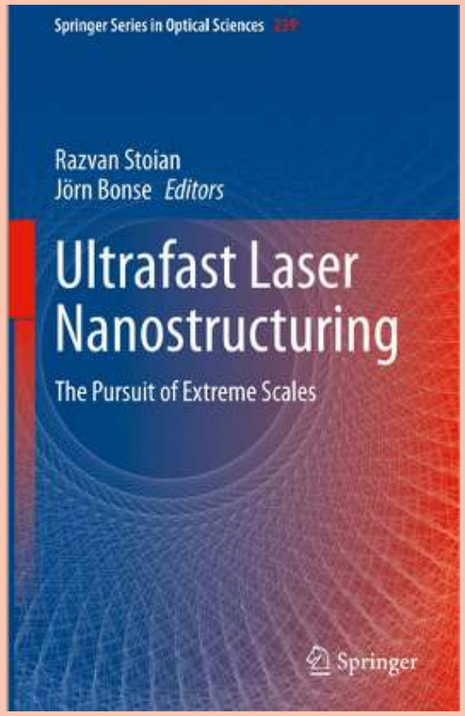
This special issue covers the interface between machine learning, spearheaded by the computing power of artificial neural networks (NN), and photonic technologies. In the past few years, there has been a renewed interest in this promising field due to a number of successful experimental demonstrations of advanced computing functionalities or the design of optimized nanophotonic devices. An example of the cross-fertilization from the combination of machine learning concepts and the advances in photonic fabrication using novel materials is the development of hardware accelerators for vector-matrix multiplication, which benefit from a software and hardware codesign. We have identified that current trends in the community can be conceptually divided in two distinct research directions. On the one hand, photonic systems and devices can serve as a hardware substrate that naturally suits the characteristic properties of artificial NN topologies. Advantages brought by photonics in this context include the potential for parallelization, high-speed operation, and low power consumption. On the other hand, machine learning can aid in the design of photonic devices or components and accelerate the search for promising structures. Artificial NN can also assist in the processing of optically acquired data with the ultimate goal of adding new functionalities and enhancing performance.

D. Brunner, M.C. Soriano, S. Fan, 'Neural network learning with photonics and for photonic circuit design', Naophotonics (2023). https://doi.org/10.1515/nanoph-2023-0123

daniel.brunner@femto-st.fr



https://www.degruyter.com/document/doi/10.1515/nanoph-2023-0123/html?lang=en



Springer
F. Courvoisier (Optics)
Chapter in « Ultrafast Laser Nanostructuring »
Edited by R. Stoian & J. Bonse

RESEARCH HIGHLIGHTS

Fully Bio-based Composites

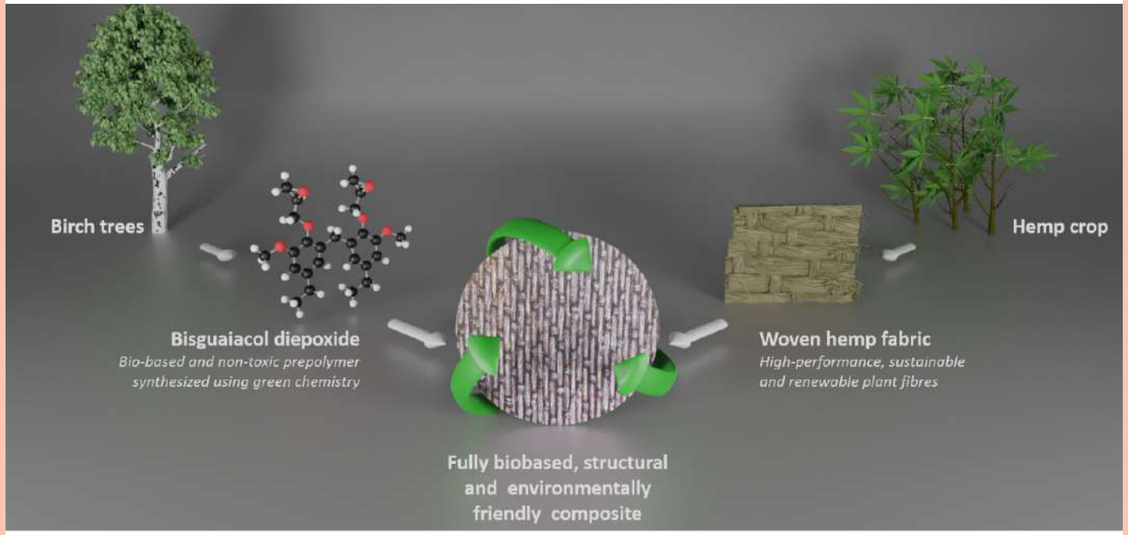
V. Placet, X. Gabrion

APPLIED MECHANICS

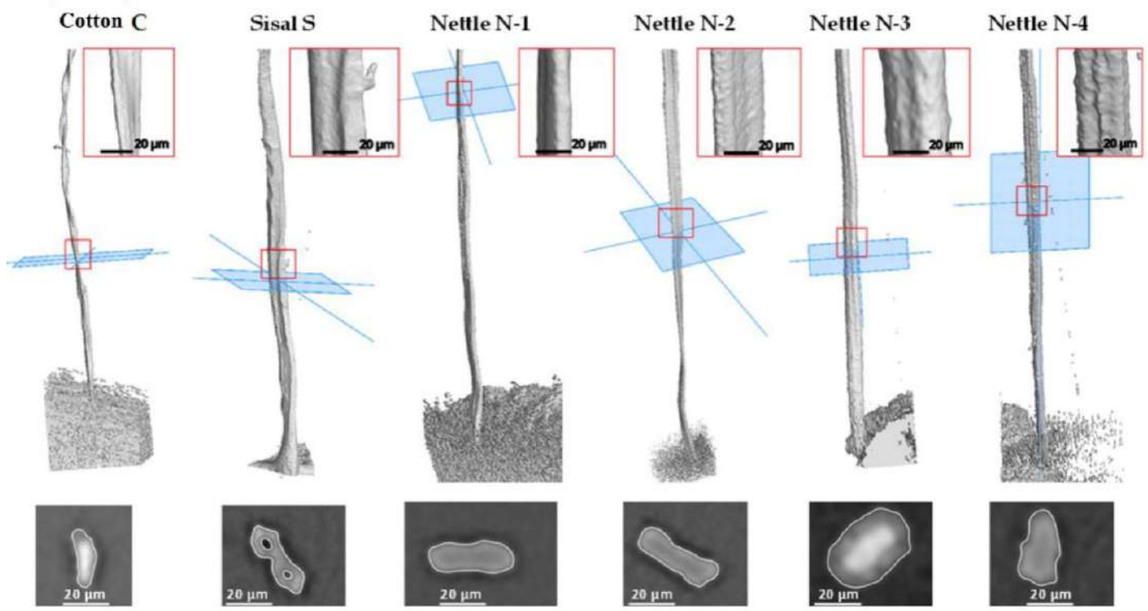
This research project is the result of a collaborative effort initiated during the EU project SSUCHY, involving the Composite Materials Group and the Center for Economics and Corporate Sustainability at KU Leuven, the Department of Organic Chemistry at Stockholm University, ICMUB, IRCM (Institut de Recherche en Cancérologie de Montpellier), and the Mat'éco Team within FEMTO-ST. The primary objective of this collaboration was to develop high-performance and environmentally-friendly composite materials. As we look to the future, materials must be biobased and produced sustainably without compromising their mechanical properties. Unfortunately, in many cases, the environmental impact of the production process often negates the advantages of using bio-based raw materials. In this study, we have introduced a novel composite material based on woven hemp fabric, which reinforces a thermoset polymer derived from birch bark, a low-value forestry byproduct. The results demonstrate that this fully biobased composite possesses specific stiffness and strength equivalent to those of flax fiber-reinforced petroleum-based epoxy composites, and only slightly lower than glass fiber-reinforced petroleum-based epoxy composites. Furthermore, a life-cycle assessment from cradle to gate has revealed that the sustainability of this material significantly outperforms commercial benchmark materials in terms of its potential global warming impact. Additionally, toxicology studies have confirmed the absence of endocrine-disrupting activities. This study serves as a vital proof of concept, demonstrating that sustainable, biobased structural materials can be manufactured without compromising performance, environmental impact, or safety.

K. Witthayolankowit et al., Composites Part B (2023). https://doi.org/10.1016/j.compositesb.2023.110692

vincent.placet@univ-fcomte.fr



A fully biobased and non-reprotoxic epoxy polymer and woven hemp fabric to prepare environmentally friendly composite materials with excellent physical properties (graphics credit: B. Guichardaz).



The NICE (Nisin controlled gene expression) system for soluble (cytoplasmic and excreted) and membrane protein expression in Lactococcus lactis

Collaboration with Tampere University & INRIA

V. Placet, X. Gabrion, C. Clevy

APPLIED MECHANICS, AS2M

Tampere University: P. Kallio
INRAE: J. Beaugrand, S. Guessasma

Plant fibers are increasingly being utilized as reinforcement for bio-based composites, with their mechanical properties significantly impacting the final composite characteristics. The orientation of cellulose microfibrils within plant fibres is one of the main factors influencing their mechanical properties. It is, therefore, of interest to obtain reliable information about the microfibril angle (MFA) to better support the choice of fibres depending on the product requirements. In 2022, a collaborative research initiative was launched, bringing together the research groups of Professor Pasi Kallio at Tampere University, Dr. Johnny Beaugrand at INRAE Nantes, and the teams ROBIMSS (Cédric Clévy, AS2M), Mat'éco (Vincent Placet, DMA), and the MIFHySTO platform (Xavier Gabrion, DMA) at FEMTO-ST Institute. The primary aim of this collaboration was to investigate the reliability and unique capabilities of three non-destructive methods: X-ray diffraction, second harmonic generation, and transmission ellipsometry microscopy. Three types of plant fibres, including nettle (with low MFA values) and cotton and sisal (with high MFA values), were compared and characterized in terms of their geometry and biochemical composition. The results obtained from these analyses confirmed that MFA analysis remains a complex task. Despite their limitations, the methods were found to be complementary, depending on the specific information required.

E. Richely et al., Composites Part C (2023). https://doi.org/10.1016/j.jcomc.2023.100355

vincent.placet@univ-fcomte.fr

RESEARCH HIGHLIGHTS

Controllable Micro-Scale Mechanical Metamaterial

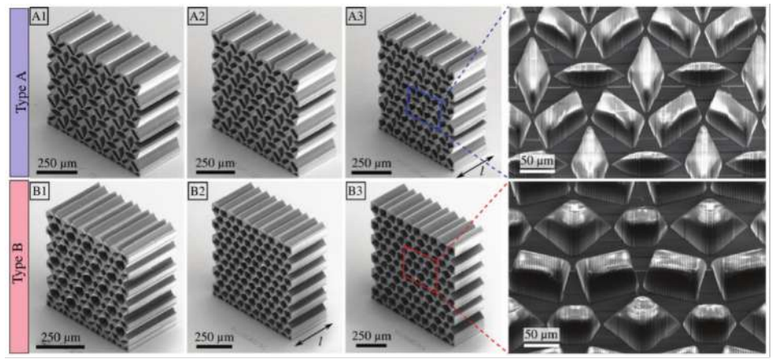
K.K. Dudek, J.A. Iglesias Martínez, G. Ulliac, L. Hirsinger, L. Wang, V. Laude, M. Kadic

MN2S

The ability to significantly change the mechanical and wave propagation properties of a structure without rebuilding it is currently one of the main challenges in the field of mechanical metamaterials. In this work, a novel micro-scale mechanical metamaterial is proposed that can undergo a transition from a configuration with a very negative Poisson's ratio to another one with a highly positive Poisson's ratio. Furthermore, it is experimentally shown that the reconfiguration process can be induced and controlled remotely through application of a magnetic field, by using appropriately distributed magnetic inclusions. This could be useful for the design of smart vibration dampers and sensors.

K. Dudek et al., Advanced Materials 35, 2210993 (2023). https://doi.org/10.1002/adma.202210993

muamer.kadic@univ-fcomte.fr



Different stable configurations of a micro-scale mechanical metamaterial with a controllable transition in the Poisson's ratio and band gap formation.

Integration of LiNbO3 Thin Films

S. Margueron, M. Ouhabaz, D. Belharet,
A. Bartasyte

TIME & FREQUENCY

The development of bulk acoustic wave filters with ultra-wide passbands and operating at high frequencies for 5th and 6th generation telecommunication applications and micro-scale actuators, energy harvesters and sensors requires lead-free piezoelectric thin films with high electromechanical coupling compatible with Si technology. A comprehensive review of the symmetry and properties of lead-free materials and their potential in vibrational energy harvesting or actuation applications has been carried out by Bartasyte and co-authors [1]. This includes the comparison of the equivalent bulk materials, the estimation of the substrate clamping effect in the thin film and the identification of their highly coupled orientations. It is shown that $LiNbO_3$ can meet all the requirements and can replace $PbZr_{1-x}Ti_xO_3$ (PZT) in MEMS and mesoscale applications.The PiezoMEMS team has developed the microfabrication process of piezoelectric microelectromechanical systems based on 5 µm thick $LiNbO_3$ films on SiO_2/Si substrate at wafer scale, including deep dry etching of thick single crystalline $LiNbO_3$ films by implementing the pulsed mode of Ar/SF_6 gas [2]. The fabricated piezoelectric MEMS have demonstrated highly linear displacement with good sensitivity (5.28 ± 0.02 µm/V) as a function of applied voltage and high vibration sensitivity of 667 mV/g, indicating the suitability of the structure for actuation purposes and for high-precision acceleration or frequency sensing, respectively.

In collaboration with INL (Lyon), IJL (Nancy), SIMAP (Grenoble) and Annealsys (SME, leader in CVD & RTP equipment, Montpelier), the epitaxial growth of 36°Y-X $LiNbO_3$ films by direct liquid chemical vapour deposition on Si substrates was demonstrated for the first time using epitaxial $SrTiO_3$ layers grown by molecular beam epitaxy [2]. The piezoelectricity of the 36°YX $LiNbO_3$/$SrTiO_3$/Si epitaxial films was confirmed by atomic force microscopy measurements and the ferroelectric domain inversion was achieved at 85 $kV.cm^{-1}$, as expected for the near stoichiometric $LiNbO_3$. In the state-of-the-art only Z-axis oriented $LiNbO_3$ films offering electromechanical coupling < 7% were attained. According to theoretical calculations, 36°Y-X $LiNbO_3$ films on Si could provide an electromechanical coupling of 24.4% for thickness extension excitation of bulk acoustic waves and a figure of merit for actuators and vibrational energy harvesters comparable to that of standard PZT films.

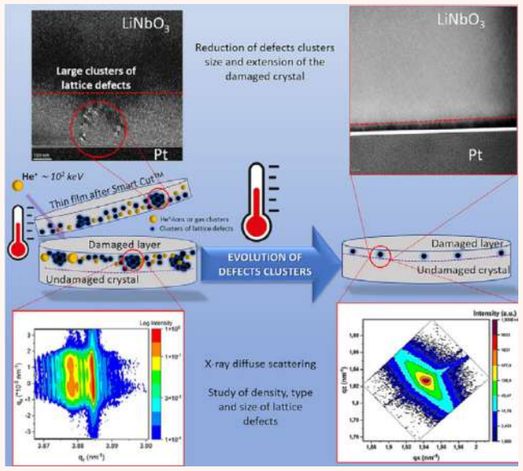
The PiezoMEMS team has also contributed to the optimisation of the recovery annealing of ion-sliced crystalline $LiNbO_3$ thin films developed by CEA LETI through advanced characterisation of the recovery by Raman spectroscopy and spectroscopic ellipsometry [3]. It has been shown that some defect clusters remain after annealing and that in-plane stresses are generated.

[1] *A.Bartasyte et al., Journal of Micromechanics and Microengineering 33, 053001 (2023). https://doi.org/10.1088/1361-6439/acbfc0*

[2] M. Ouhabaz et al., & Bartasyte et al. in special issue "Focus on RENATECH", Nanotechnology (2024), IOP Science. https://iopscience.iop.org/journal/0957-4484/page/focus-renatech

[3] S Dolabella et al., Materials & Design 231(18):112001 (2023). https://doi.org/10.1016/j.matdes.2023.112001

ausrine.bartasyte@femto-st.fr



Reducing the irradiation damage in materials processed by crystal ion slicing (CIS) is pivotal for recovering the properties linked to the material structure, which enables the performance of related devices.

Introducing a New Optimization Parameter Based on Diffusion, Coalescence and Crystallization to Maximize the Tensile Properties of Additive Manufacturing Parts

K. Benié, T. Barrière, V. Placet
A. Cherouat (UTT/UR-GAMMA3)

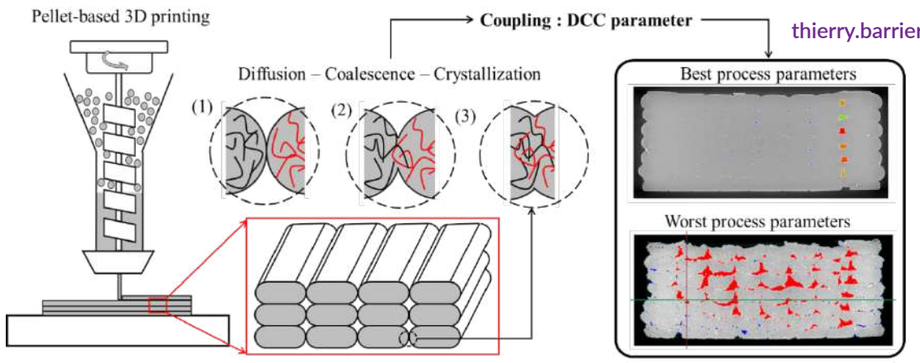
APPLIED MECHANICS

A new physical parameter has been introduced to optimise additive manufacturing (AM) process parameters to maximise the mechanical properties of printed parts while avoiding costly experiments related to printing and mechanical testing.

This parameter, derived from the main physical phenomena involved in the 3D printing process, namely diffusion, coalescence and crystallisation, has been named DCC. It takes into account the interdependence between the physical phenomena and is fed by the temperature profile at the interface of adjacent strands and layers. The study of the DCC parameter on PolyLactic Acid and PolyPropylene materials, taking into account various process parameters, has shown that it is an excellent indicator of the level of mechanical performance of the printed parts and can be used advantageously to tune the process parameters. This study establishes the first business rules for AM of short plant fibre reinforced bio-composite materials in terms of printing mechanical properties, failure mechanisms, deposition strategy and feeding multi-physics simulation tools for 3D printing.

K. Benié et al., Additive Manufacturing 69, 103538 (2023), https://doi.org/10.1016/j.addma.2023.103538

thierry.barriere@univ-fcomte.fr



Determining the best process parameters with the DCC study.

SCHOOLS, WORKSHOPS & CONFERENCES

Euromech Colloquium 636:
Modulation of physico-chemical processes by elastic strain-engineering

May 22-24, 2023, Besançon

Chairs: F. Amiot (FEMTO-ST), SJ. Llorca (Pol. U. Madrid)

21 participants

https://636.euromech.org/

ICRA 2023 Workshop
Origami-based structures for designing soft robots with new capabilities

May 29, 2023, London

Chairs: S. Viollet (main organizer, Institut of Movement Sciences), J. Paik (EPFL), K. Rabenorosoa (FEMTO-ST), C. Sung (Univ. Pennsylvania), P. Renaud (ICube), M. Kovac (Imperial)

50 participants

https://www.origabot.cnrs.fr/workshop-icra-2023

APVP 2023
Le 13ième Atelier sur la Protection de la Vie Privée

June 12-15, 2023, Arc-et-Senans

Chair: J.F Couchot (FEMTO-ST)

70 participants

https://apvp23.sciencesconf.org/

EFTS
European Frequency and Time Seminar

June 26-30, 2023, Besançon

Chair: E. Rubiola (FEMTO-ST)

35 participants

http://efts.eu

JNC23
Journées Nationales sur les Composites

July 3-5, 2023, Besançon

Chairs : F. Thiébaud, V. Placet (FEMTO-ST)

250 participants

https://jnc23.sciencesconf.org/

FACS-Formal Aspects of Component Software
October 19-20, 2023, Online

20th Anniversary Chair: O. Kouchnarenko (FEMTO-ST)

https://facs-conference.github.io/2023/

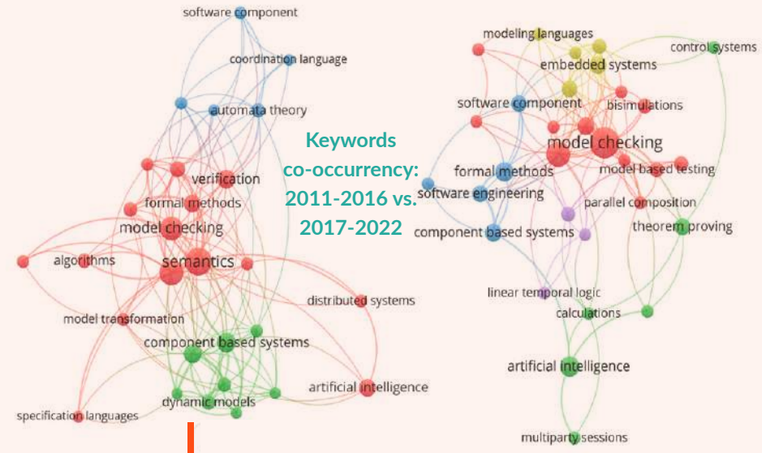
A bibliometric analysis of the proceedings of the eighteen editions (2003-2023) of the International Conference FACS was done, in order to perceive its achievements and evaluate its impact on the community by addressing two questions: How to identify, measure and exploit the impact of FACS? How to perceive the evolution of FACS themes over the years? The presentation first describes a research methodology before providing the audience with an overview of the results of the advanced queries. Second, the topics and themes covered are highlighted and their evolution over the two decades of FACS are described. Finally, Open Access issues are discussed. *(O. Kouchnarenko and L. Robert, FACS Proceedings, 2023)*

ETAI 2023
Emerging Topics in Artificial Intelligence

August 18-22, 2023, San Diego

Organizers: G. Volpe (Göteborgs U.), J. B. Pereira (Karolinska Institute), D. Brunner (FEMTO-ST), A. Ozcan (UCLA)

https://spie.org/op23n/conferencedetails/emerging-topics-in-ai



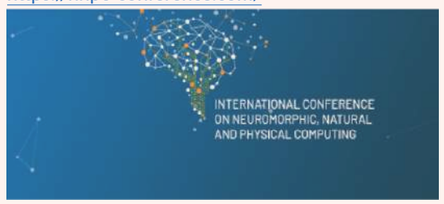
NNPC
International Conference of Neuromorphic, Natural and Physical Computing

October 25-27, 2023, Hannover

Chairs: D. Brunner (FEMTO-ST), G. Pipa (U. Osnabrück), S. Stepney (U. York), P. Querlioz (U. Paris-Saclay)

120 participants

https://nnpc-conference.com/



Annual Days GDR EX-MODELI
Exploiting and Modeling of Nonlinearities

November 9-10, 2023, Besançon

Chairs : E. Sadoulet-Reboul (FEMTO-ST)

90 participants

https://events.femto-st.fr/GdR-EX-MODELI/

Colloque SDH
Le renouveau des grandes enquêtes en démographie historique: Créer et partager les données en histoire des populations

November 23-24, 2023, Aubervilliers

Organizers: L. Heyberger (FEMTO-ST)

70 participants

www.societededemographiehistorique.fr

NEW EUROPEAN PROJECTS

HORIZON-RIA- CL4-2023-HUMAN-01-01

RAIDO - Reliable AI and Data Optimization

C. Clevy, V. Placet

AS2M & APPLIED MECHANICS

RAIDO is a powerful framework for developing trustworthy and green artificial intelligence (AI). Trustworthy AI focuses on ensuring the reliability, security, and unbiased optimisation and deployment of AI systems. RAIDO uses automated data curation methods, such as digital twins, to create high-quality, unbiased training data. It also provides data- and compute-efficient models for energy-efficient AI, using methods such as few- and zero-shot learning. RAIDO ensures transparency and reliability through explainable AI methods, decentralised blockchain, and an innovative AI orchestrator, reducing overall energy consumption in development and deployment. The project will be evaluated through four real-world demonstrators in key application areas such as smart grids, computer vision-based smart agriculture, healthcare, and robotics, demonstrating notable societal and market impacts.

In this project, UBFC/FEMTO-ST will be responsible for the demonstrator in the robotics domain, which is the result of a historical collaboration between AS2M and Applied Mechanics, and will be entitled "Industry 5.0 & Bio-based Composites, AI Models for Plant Fibre Characterisation".

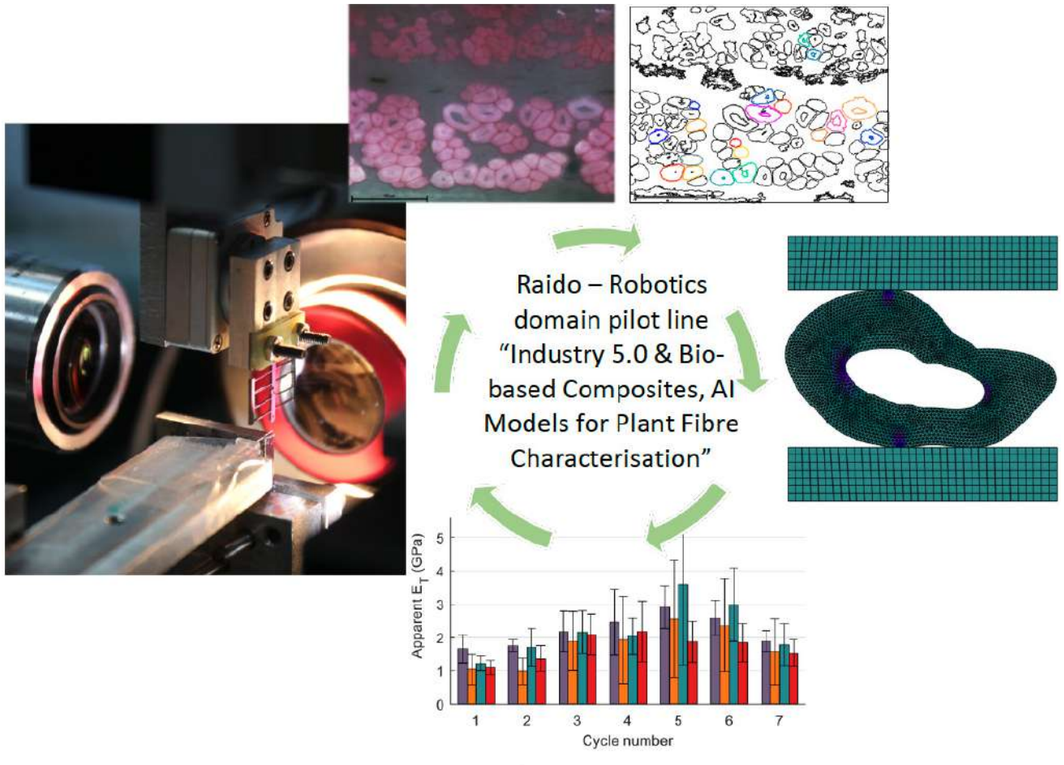
Consortium:

Inst. Joseph Stefan (Coordinator-SI), Ubitech (CY), Netcompany-Intrasoft (LU), Ayesa (ES), Fujitsu (LU), Metamind Innov. (EL), Trinity College London (IE), The awareness movement (CY), Krechnologies (BE), Chelenic Ntainamiks (UK), Vito (BE), Sidroco (CY), UBFC-FEMTO-ST (FR), Eight Bells LTD (CY), Mathema (IT), CRT Hellas (EL), Cyberjab (IE), Dimosia (EL), Axon logic (EL), Adrestia (EL), Logos Ricerca (IT), Jessa (BE), TWI Ellas (EL)

Total funding: 9 M€

FEMTO-ST funding: 450 k€

cclevy@femto-st.fr



HORIZON Research and Innovation Actions

HORIZON-CL4-2023-DIGITAL-EMERGING-01-53

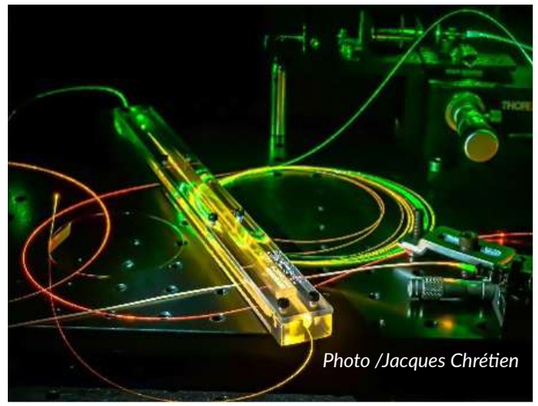
uCAIR - Ultra-Fast Chemical Analysis Imaging with Raman

J.-C. Beugnot. G. Fanjoux

OPTICS

uCAIR brings together successful R&D photonics SMEs and research laboratories in optics and cell biology to create an innovative, versatile and practical multimodal photonics platform that will improve and accelerate the way cells are studied by scientists and healthcare professionals. uCAIR will achieve breakthrough results by developing a laser platform that inventively combines non-linear optical fibres, optronics, broadband coherent Raman and IA technologies.

Consortium: Coord. Univ. LIMERICK (IR), Multi-tel (BE), Univ. Jena (DE), Univ. Leibniz (DE), Univ. Altinbas (TR), Lambda-X (DE), Phot. Bretagne (FR), FEMTO-ST/CNRS (FR)



Nonlinear conversion of light in tapered silica optical fiber manufactured at Optique/ONL nanofiber draw facility.

Total funding: 5 M€

FEMTO-ST funding: 223 k€

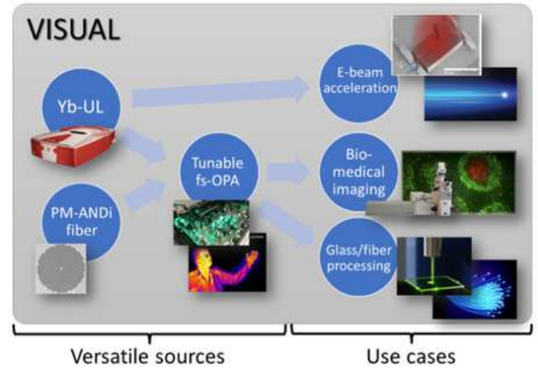
jc.beugnot@femto-st.fr

VISUAL - Versatile Infrared Light Source for Advanced Illumination

T. Sylvestre

OPTICS

The VISUAL project aims to strengthen the leading position of the industrial partners in the production of ultrafast lasers for scientific, medical and industrial applications, based on a novel design-to-cost and innovative femtosecond laser platform with unprecedented technical versatility. This high average power platform will deliver ultrashort optical pulses with pulse-on-demand capability at very high repetition rates (60 MHz) and with an extremely wide wavelength tuning capability. The many advantages of this multipurpose platform will be evaluated at VISUAL in the fields of label-free bio-imaging and medical diagnostics, on-chip particle acceleration for electron beam therapy, and advanced fibre and glass microstructuring.



Outcomes of the VISUAL proposal.

Consortium: Coord. Fastile (FR), Amplitude (FR), CNRS: FEMTO-ST, INPHYNI, PHLAM (FR), JenLab GMBH(DE), UITM (PL), Friedrich-Alexander Univ. (DE)

Total funding: 4.1 M€

FEMTO-ST funding: 450 k€

thibaut.sylvestre@univ-fcomte.fr

NEW EUROPEAN PROJECTS

INTERREG VI Franco-Suisse (RIA-IA)

DISTANCE - Distributed Sensor with Ultra Long-distance Optic Fibre

J-C. Beugnot; K. P. Huy, G. Fanjoux, J. Salvi

OPTICS

The project will produce a prototype of a distributed temperature fibre optic sensor for monitoring wind-generated electrical energy over distances up to three times greater than currently possible. The applications of this technology will allow better exploitation of the wind potential in deep waters, thanks to a sensor that operates without loss of sensitivity or measurement resolution over distances of more than 150 km, which are currently inaccessible.

Consortium: Coord. UFC/FEMTO-ST (FR), Aurea Technology(FR), Haute Ecole Saint Imier (CH) Omnisens/Prysmian (CH)

Total funding: 1 M€

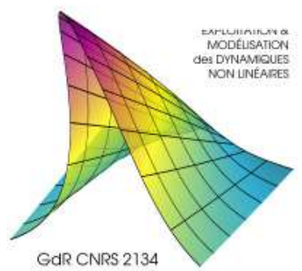
FEMTO-ST funding: 480 k€

jc.beugnot@femto-st.fr

Photograph of the experimental test bench in the optics lab for the demonstration of ultra-long distributed Brillouin fiber sensor measurements.

NEW NATIONAL NETWORKS

GDR Ex-MODELI Exploiting and Modeling of Nonlinearities



E. Sadoulet-Reboul

APPLIED MECHANICS

Ex-MODELI brings together the French academic and industrial community in the field of nonlinear dynamics on the three main themes of the GdR: the exploitation and modelling of nonlinearities, the control of multiphysical couplings integrating these nonlinearities, and experimental and numerical analysis methods for nonlinear systems. Supported by the CNRS since January 2023, the GdR is attached to the CNRS Engineering institute (INSIS), and more specifically to Section 09.

Coordinators: E. Sadoulet (FEMTO-ST), E. Denimal Goy (INRIA), O. Thomas (ENSAM LISPEN), C. Touze (ENSTA IMSIA)

https://events.femto-st.fr/GdR-EX-MODELI/

gdr-exmodeli-bureau@groupes.renater.fr

emeline.sadoulet-reboul@univ-fcomte.fr

GDR I-GAIA Engineering Augmented by Data, Learning and AI

D. Brunner, S. Cogan

OPTICS, APPLIED MECHANICS

The engineering sciences have achieved a proven maturity in modelling, simulation and testing that has enabled unprecedented technological developments. Existing models, the legacy of fruitful centuries of science, have been validated and calibrated and have proven to be accurate and robust. As models have 'grown up' in the 21st century, a new set of challenges has emerged: the need to deal with ever larger systems and behaviours, and in short, we need new ways of doing things quickly and well. The GDR I-GAIA provides an umbrella for the French engineering community, with the mission of enhancing current engineering methodology with concepts derived from artificial intelligence.

Coordinator: F. Chinesta (ENSAM Arts et Métiers)
Co-coordinators: E. Baranger (ENS Paris-Saclay), P. Sagaut (Aix-Marseille Université), D. Brunner (FEMTO-ST)

https://gdr.igaia.cnrs.fr/

daniel.brunner@femto-st.fr

FACILITY HIGHLIGHTS

FEMTO-ST key facilities are grouped into centres in order to make them accessible not only to FEMTO-ST members, but also to teaching activities and to regional, national and international industrial and academic partners for their research and/or development projects:

AMETISTE

Mechanical characterization of materials, surfaces and structures in a wide range of dimensions and frequencies

CLIPP

Clinical innovation proteomic facility, know-how in (bio) chemistry, physico-chemistry, nano- and micro-engineering, biostatistics and bioinformatics

CMNR

Robotics centre offering services in micro/nanocomponents, characterization, manipulation and micro-assembly

FLUIDIX

Facility for fluidic and thermal characterization of complex flows

FRANCHE-COMTE MESOCENTRE

Numerical simulation, high-performance computing

HYDROGEN ENERGY (FCLAB)

Hydrogen-energy and testing of fuel cell systems, durability of energy sources for electric and hybrid vehicles and for stationary applications.

MIFHySTO

Micromanufacturing, mechanics, micromachining, powder injection molding, metal additive manufacturing, surface

MIMENTO

Microfabrication for Mechanics, Nanosciences, Thermal Science and Optics

OSCILLATOR IMP

Oscillator instability measurements, frequency references (from RF to optics) and state-of-the-art comparative measuring instruments

SMARTLIGHT

Photonics for AI and AI for Photonics facilities (photonics & optoelectronics state-of-the-art equipments)

SURFACE

Development and characterization of thin-film materials

https://www.femto-st.fr/fr/Plateformes-technologiques/Mimento-presentation

https://www.femto-st.fr/fr/Plateformes-technologiques/autres-plateformes

Access to Thermofluidic Parameters: Temperature and Species Concentration Measurements in Reactive Flow

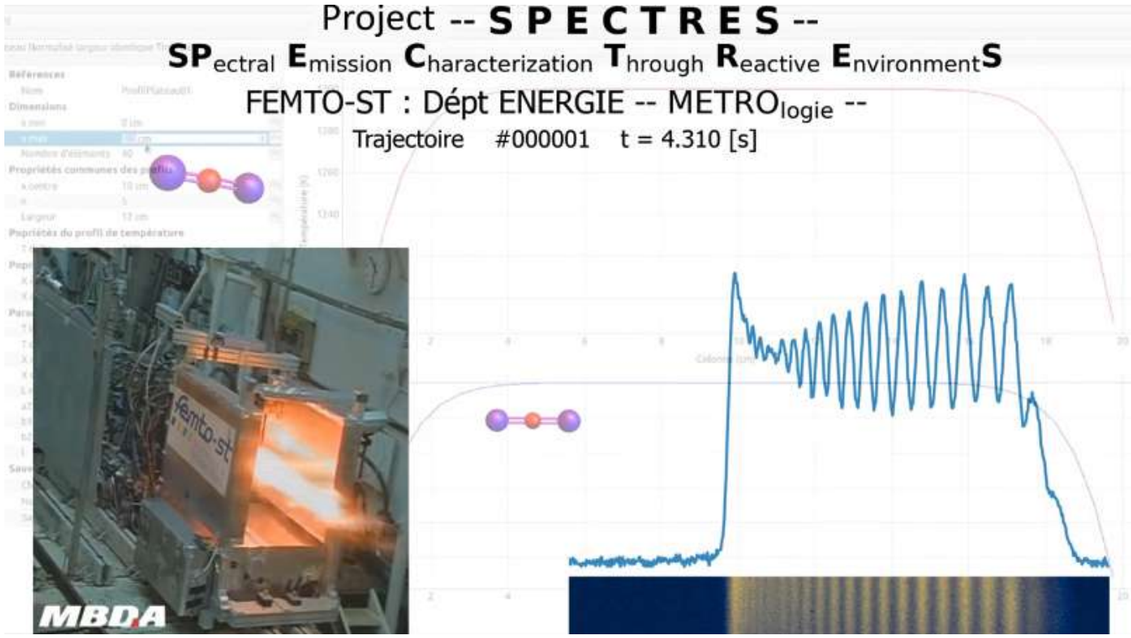
D. Ramel, D. Bonnet, Y. Bailly, L. Girardot, F. Guermeur, S. Vives, L. Callegari, B. Rothlisberger, D. Surdyk

FluidiX

The FLUIDIX technical research facility (FEMTO-ST Institute) provides access to the thermofluidic quantities of different flows, thanks to the development of new and existing measurement methods. The aim of the SPRECTRES (SPectral Emission Characterisation Through Reactive EnvironmentS) project presented here is to provide a complete and innovative tailor-made measurement system for the characterisation of combustion at the output of industrial propulsion systems. This unique set includes, on the one hand, the complex optical and mechanical part responsible for the acquisition of luminance spectra produced by certain chemical species present in the flow and, on the other hand, electronic and software elements. This measuring instrument has been tested and subjected to the severe constraints imposed by the industrial complex flow (vibrations, sound waves, temperatures and turbulence, etc.) and atmospheric conditions (outdoor test benches: rain, sun, snow, temperatures, etc.). Theoretical developments, fed by databases and by the establishment of the transfer function of our metrological system, have made it possible to create the software for analysing the acquired data in order to provide spatial distributions of temperature and concentration of the target chemical species.

https://www.femto-st.fr/sites/default/files/fluidix2022.pdf

laurent.girardot@univ-fcomte.fr



Device measurement on industrial bench, experimental spectrum luminance and data analysis software to deduce spatial temperature distribution.

FACILITY HIGHLIGHTS

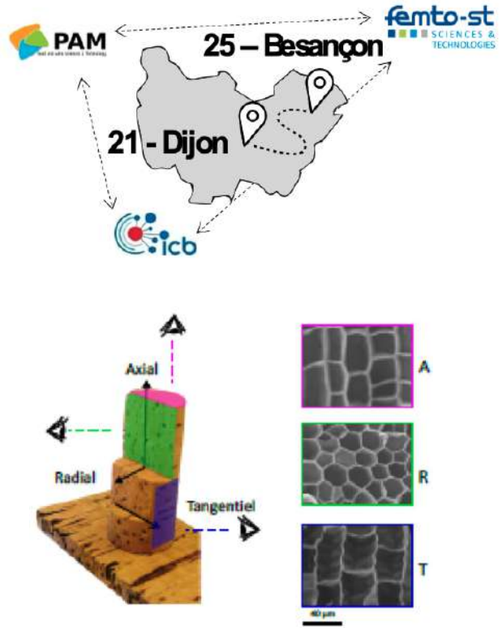
Analysis of Cork Stopper Porosity by Nano-Micro-X-ray Tomography

X. Gabrion, S. Thibaud

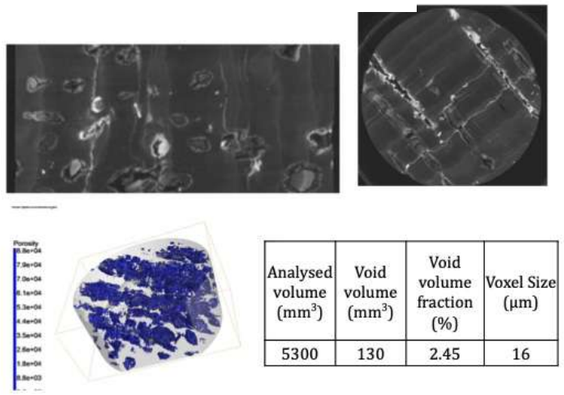
MIFHySTO

X-Plore project involves two laboratories in Bourgogne-Franche-Comté region: UMR PAM of Dijon (Agro Dijon Institute) and FEMTO-ST. The aim of this project is better understanding of the relationship between the mechanical properties and the gas barrier properties of cork stoppers and, at the end, understanding of the transfer phenomena involved in wine preservation. Some mechanical studies [1-4] have already been carried out at the cork stopper scale, these studies have led to a better understanding of the deformation mechanisms of the cork cell by coupling mechanical tests and scanning electron microscopy (SEM). However, this information provides a two-dimensional cartography of the deformation. Nanotomography (at the microscopic level, specimens with a diameter of 1 mm and a height of 2 mm), coupled with mechanical testing, helped to understand the deformation mechanisms present under the first layer visible in the SEM and in the three different directions of the material.

[1] K. Crouvisier-Urion et al., Sci. Rep. 9, 19682 (2019). https://doi.org/10.1038/s41598-019-55193-9.
[2] A. Lagorce-Tachon et al., Poromechanics VI, 8 (2017).
[3] A. Lagorce-Tachon et al., J. Mater. Sci. 51, 4227 (2016). https://doi.org/10.1007/s10853-015-9669-6.
[4] H. Pereira, Bioresources. 10 (2015).
[5] G. Massimiliano et al., Materials and Design 235, 112376 (2023), https://doi.org/10.1016/j.matdes.2023.112376



SEM image of the cell of cork stopper.



Analysed volume (mm^3)	Void volume (mm^3)	Void volume fraction (%)	Voxel Size (µm)
5300	130	2.45	16

Analysis of cork stopper for the determination of the internal porosities at macroscopic level.

In-situ micromechanical test machine.

https://www.femto-st.fr/fr/Plateformes-technologiques/autres-plateformes

xavier.gabrion@ens2m.fr

Die Sinking Electrical Discharge Micromachining

L. Guiziou, E. Ramasso, S. Thibaud

MIFHySTO

As part of an industrial partnership, the MIFHySTO facility has acquired a new electric discharge machine (EDM), the FORM S 350. This new GFMS-brand precision machining centre is capable of producing profiles with dimentions down to 50 micrometers with repositioning repeatability in the micrometer range, thanks to its thermal stabilisation. It stands out from the competition thanks to its high configurability of the control parameters, allowing the operator to optimise the balance between speed and quality. The instrumentation of the machine to continuously extract machining status information was developped in the framework of the PhD thesis project. This includes accessible data on voltage, current and acoustic emission, enabling the user to identify machining problems on complex materials.

In addition to its micrometer-level performance, the machine is capable of forming larger shapes (530x300 mm^2) on standard conductive materials, with settings pre-defined by the manufacturer and regularly updated. Finally, the FORM S can produce sharp edges without the limitations of a conventional tool radius and also achieves a homogeneous and low roughness surface finish.

Die sinking electrical discharge machining

mifhysto@femto-st.fr

"sciFLEXARRAYER S3" Nanospotter

W. Boireau, J. Dejeu, A. Rouleau

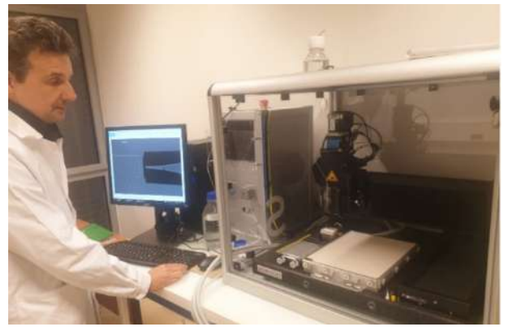
CLIPP

A unique facility for the building of multiplexed biochips in µarrays & biointerfaces on nano/micro-structured materials

With a view to biochip development, CLIPP has recently purchased a "sciFLEXARRAYER S3" NanoSpotter from Scienion Company. The design of the stage allows high speed operation by automation and ensures accurate sample deposition and reproducible spot allocation at the µm scale (resolution & precision) on different substrates. This equipment opens up new possibilities for chemical functionalisation and patterning by dispensing ultra-low volumes (from 30 to 800 pL/droplet) via a piezoelectric actuator. Biochemical solutions are also processed to allow the grafting (or adsorption) of biological or synthetic receptors in µarray formats. CLIPP aims to produce biochips with a high density of spots (from 96 to 384) to increase multiplexing in the detection of target molecules. The first application will be for surface plasmon resonance imaging techniques, which will take advantage of multiplexing to detect biological targets simultaneously, while increasing the robustness of the detection by inserting numerous control spots in the pattern. The technology will also be suitable for the construction of various types of biointerfaces, such as extracellular matrices for cell culture or trapping. In addition, the large target holder will be adapted to a wide range of substrates (wafers, glass slides, microplates, microfluidic structures...), offering new possibilities for extremely non-contact dispensing of aqueous and organic solvents.

www.clipproteomic.fr

wboireau@femto-st.fr



"sciFLEXARRAYER S3" Nanospotter in operation by Alain Rouleau in the "µarrays room" of the CLIPP facility.

FACILITY HIGHLIGHTS

FEMTO-ST now has its own Neuroscience Facility

J.-J. Aucouturier

Human Sensory Electrophysiology Lab, AS2M

Over the last 3 years, the AS2M department has developed a new line of medical engineering research that applies control engineering methods to the study of human neurological pathologies such as stroke or coma. While clinical studies with patients are carried out in collaboration with hospital institutions, including Hôpital Pitié-Salpêtrière or Hôpital Sainte-Anne in Paris, the development of such technologies requires preliminary studies with healthy controls at FEMTO-ST. Thanks to funding from SUPMICROTECH/ENSMM (PIA 2022), Région Bourgogne-Franche-Comté (ANER ASPECT project) & ERC CREAM, the AS2M department has acquired a new research facility for performing sensory electrophysiology experiments in humans, including a Boët-Stopson soundproof room, a BrainProducts EEG/EMG recording system and audiovisual stimulus presentation hardware and software. This new facility contributes to raising the level of pure life science research that can now be conducted in-house at FEMTO-ST, complementing the already existing L2 standard cell biology facilities that support the Institute's biotech research (CLIPP platform, MN2S Dept).

jean.aucouturier@femto-st.fr

PhD students Camille Des Lauriers & Zhenxing Hu conduct a scalp EEG experiment in the new FEMTO-ST Facility for human sensory electrophysiology.

New Equipments at CMNR

A. Bolopion, G. Laurent, J.-Y. Rauch

Centre of Micro & Nano Robotics (CMNR)

The Centre of Micro and Nano Robotics (CMNR) is a technology facility dedicated to the manipulation, characterisation and assembly of objects and systems with characteristic dimensions of less than 100 µm.

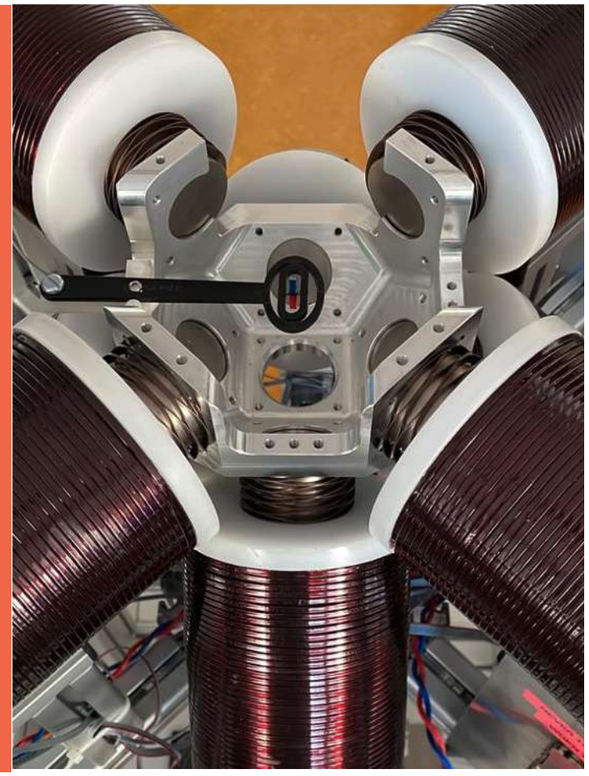
In 2023, the centre continued its development through two investments:

1. The robotization of electron microscopes (upgrading of the ZEISS microscope robot and robotization of the FEI microscope)
2. The acquisition of a magnetic navigation system for the development and testing of magnetically actuated flexible microrobots (OctoMag from MagnebotiX). The CPER research facilities programme has funded this equipment.

The Micro and Nano Robotics Centre now has 10 stations, open to academia and industry, dedicated to the manipulation and characterisation of micro and nano objects. These stations allow the manipulation of micro- and nanoscale objects in ambient air, under vacuum, inside confined spaces or inside fluidic chips, using different tools such as grippers, tips or magnetic fields. The mechanical properties of these micro- and nanoscale objects can be characterised at the dedicated stations of the Centre of Micro and Nano Robotics.

https://platforms.femto-st.fr/cmnr/fr

cmnr@femto-st.fr



The MagnebotiX OctoMag magnetic field generator offers five-degree-of-freedom (5-DOF) wireless magnetic control (3-DOF position and 2-DOF pointing orientation) in a large working volume. Forces and torques can be applied independently on magnetic materials on the micrometer to mm scale.

FACILITY HIGHLIGHTS

Renewal of the ISO 9001 Certification

M.-C. Péra, D. Bouquain, A. Djerdir, D. Chrenko

Hydrogen Energy

The Hydrogen Energy Platform will receive its first ISO 9001 certification in 2020. Since then, several improvements have been made thanks to the involvement of the technical and administrative staff: Computerised maintenance management system for all equipment, writing of procedures for the correct operation of test rooms and test benches, user incident reports, good practices for the safety of users and equipment. These achievements have been rewarded with the renewal of ISO 9001 in December 2023. We received excellent feedback from the auditor. Thanks and congratulations to the staff and in particular to Emmanuelle Arcens (Quality Manager), Xavier François (Technical Manager), Daniela Chrenko (Training Programme Manager). We also had excellent feedback from the industrial partners for the test design, measurement and analysis and training.

Monthly Quali'thé, internal seminar on quality and safety for users of the platform, given by Violaine Hell (Assistant Engineer).

www.fclab.fr

contact.fclab@utbm.fr

Tira 27 kN Shaker with Table

G. Chevalier, S. Carbillet, E. Foltête

AMETISTE

The AMETISTE (Advanced Mechanical Testing of Materials, Surfaces and Structures) facility has acquired a 27 kN shaker with vibrating table (750*750 mm^2) in 2022, funded by BFC region. This equipment enables the AMETISTE to strengthen and increase its performance in order to consolidate its identity on the national and international scene, in line with current scientific and societal issues.

This equipment, which can be subsequently linked to an environmental chamber, will also enable to respond to industrial specifications for vibration control in extreme environments (aeronautics, optronics, automotive and railways).

It complements the recently acquired vibration measurement equipment (1D and 3D laser vibrometers, high-speed cameras) to make the AMETISTE one of the best-equipped facilities in France and Europe in this field.

In fact, it has allowed to consolidate scientific partnerships with companies (notably through CIFRE theses) and to respond to expertise for companies in the region.

https://platforms.femto-st.fr/AMETISTE/fr

ametiste@femto-st.fr

Vibration tets on vibrating table, with thermal camera, accelerometer and laser vibrometer.

FACILITY HIGHLIGHTS

Low Temperature Scanning Tunneling Microscope

F. Palmino, F. Cherioux

SURFACE

Nanoscience and nanotechnology constitute a field of research based on the observation and understanding of the properties of objects with nanometric dimensions (one billionth of a meter). This involves the use of very specialised microscopes that utilize quantum phenomena, such as the tunneling effect. Such microscopes require very strict conditions to overcome parasitic phenomena that could disturb the measurements.

The SURFACE facility at FEMTO-ST, located on the campus of Portes du Jura in Montbéliard, has just acquired a scanning tunneling microscope capable of operating under ultra-high vacuum (10^{-11} mbar and at very low temperatures (-264 °C). It is exceptionally stable, with a thermal drift of around 5 pm/hour, and has a low-noise amplifier capable of producing images at 300 fA.

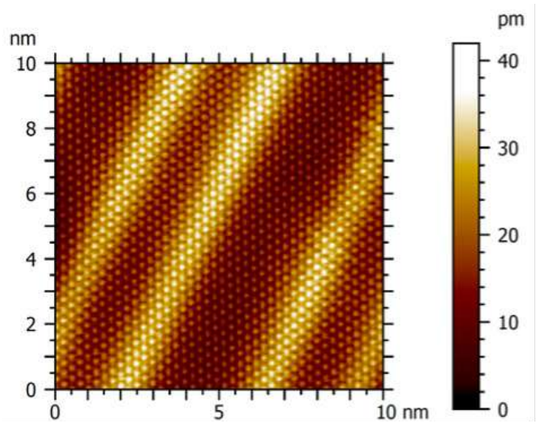
This microscope is unique in our region and was funded by the Bourgogne-Franche-Comté region, the National Research Agency, and the Pays de Montbéliard Agglomeration, for a total amount of 600 k€.

The choice of microscope model was guided by its technical performance and the researchers' strong commitment to limiting the carbon footprint of their research. The microscope has a complete system for recycling cryogenic fluids without water consumption.

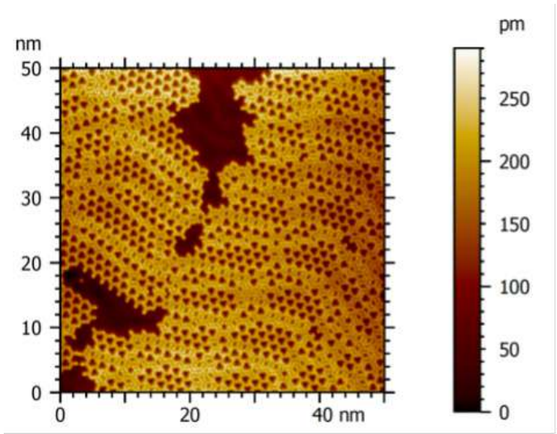
This microscope will be used to develop research with high societal impacts, such as new catalysts for CO_2 valorisation, environmental sensors for detecting pollutants in groundwater, or new devices for future electronics.

https://platforms.femto-st.fr/SURFACE/fr

frank.palmino@univ-fcomte.fr
surface@femto-st.fr



Atomic resolution on Au(111)



Supra molecular network on Au(111)

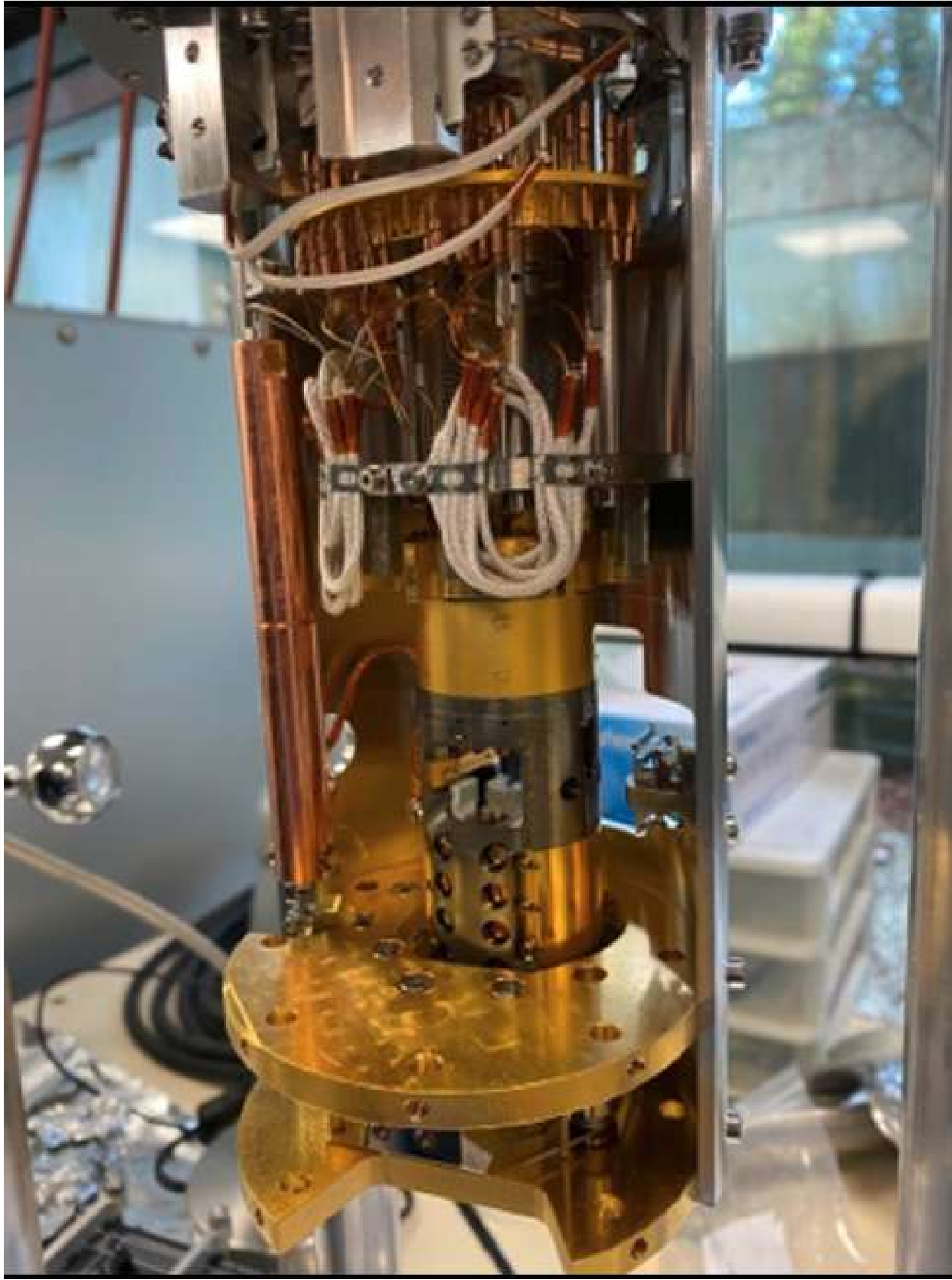


Photo of STM head

INNOVATION

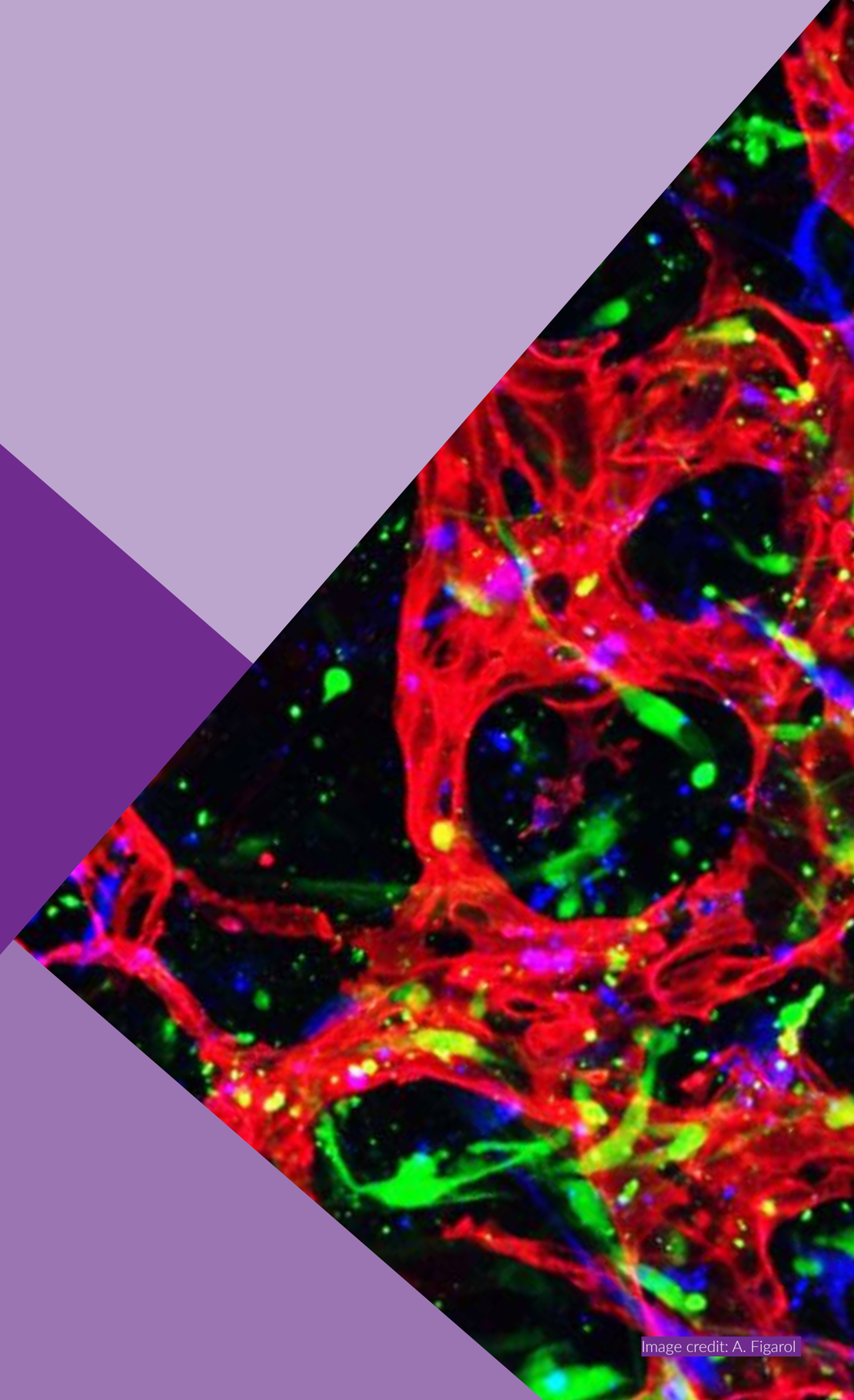


Image credit: A. Figarol

FEMTO Engineering

The Engineering Centre of the FEMTO-ST Institute offers to industry high-level engineering developments, based on research conducted at FEMTO-ST. FEMTO Engineering has sixteen employees and cooperates directly with the research groups within the FEMTO-ST Institute.

FEMTO Engineering contributed to the development of technologies from the laboratory (called proprietary technologies) and concluded contracts both with local companies and large international groups.

Technological fields:

- **Energy**
- **Optics, Photonics and Laser Machining**
- **Electronics and Hyperfrequencies**
- **Microtechnology**
- **Robotics**
- **Artificial Intelligence**
- **Mechanical Characterisation**

FACILITIES: MIMENTO, CMNR, OSCILLATOR-IMP, AMETISTE, SMARTLIGHT, MIFHySTO, Hydrogen-Energy

contact@femto-engineering.fr
www.femto-engineering.fr

FEMTO Engineering is labelled Carnot for the quality of its engineering partnerships with industrial companies.

FEMTO Engineering is a partner of Carnot Telecom & digital society.

Scanner for Fuel Cell Diagnostics

This new diagnostic technology allows fuel cell manufacturers to benefit from a non-invasive means of end-of-line control to ensure the quality of the performance achieved.

With the advent of electric vehicles, hydrogen energy is a rapidly developing option for powering vehicles with high levels of autonomy.

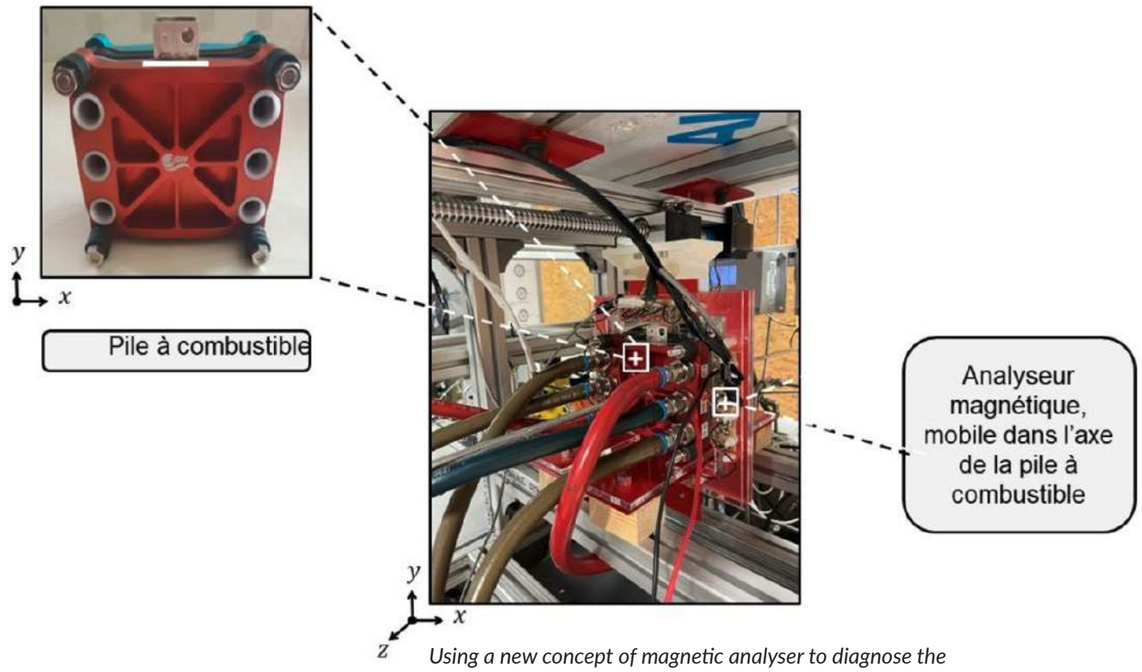
The SHARPAC research team at the Energy Department of the FEMTO-ST Institute in Belfort has developed a new technology to analyse and detect faults in fuel cells by measuring the magnetic field. By passing magnetic field sensors around the axis of the cell, it is possible to identify and locate possible internal defects without having to dismantle the cell.

A test bench available to industry!

FEMTO Engineering, the engineering centre of the FEMTO-ST Institute, is developing a test bench to carry out tests close to industrial production lines. This bench automates the entire measurement chain and automatically analyses the results.

These technological developments have received financial support from the Bourgogne-Franche-Comté Region.

olivier.lehmann@femto-engineering.fr



Using a new concept of magnetic analyser to diagnose the operating state of a fuel cell (Ali Bawab's thesis - FEMTO-ST)

Numerical Simulations, Design and Fabrication of Optical Diffractive Components

From TRL4 up to TRL6

For many years, the FEMTO-ST Optics department has been developing numerical simulation skills dealing with the interaction between light and periodic structures.

With the aim of developing an integrated optical component capable of coupling an optical wave emitted by a laser or LED and carrying data in an optical fibre or in a photonic optical circuit, FEMTO-Engineering, in close collaboration with FEMTO-ST, has succeeded in performing numerical simulations using FFM and FDTD methods (Fig. 1). The numerical results obtained have been used to define grating characteristics for a microfabrication and femtosecond laser manufacturing.

Thanks to the MIMENTO clean room facilities, thin film deposition, electronic lithography and plasma etching technologies were used to produce the focusing grating (Fig. 2 left). The second grating was made using a femtosecond laser, exploiting the beam shaping technique and the holographic principle. Thanks to the micrometric tiny size of the Bessel beam, sub-micrometric tracks and dots were laser induced in the glass substrate, allowing the fabrication of the optical grating in less than 1 hour. Finally, thanks to the facilities of the Optics department, the performance of both gratings were optically characterised using visible laser, tunable laser and LED sources (Fig. 2 right).

jassem.safioui@femto-engineering.fr

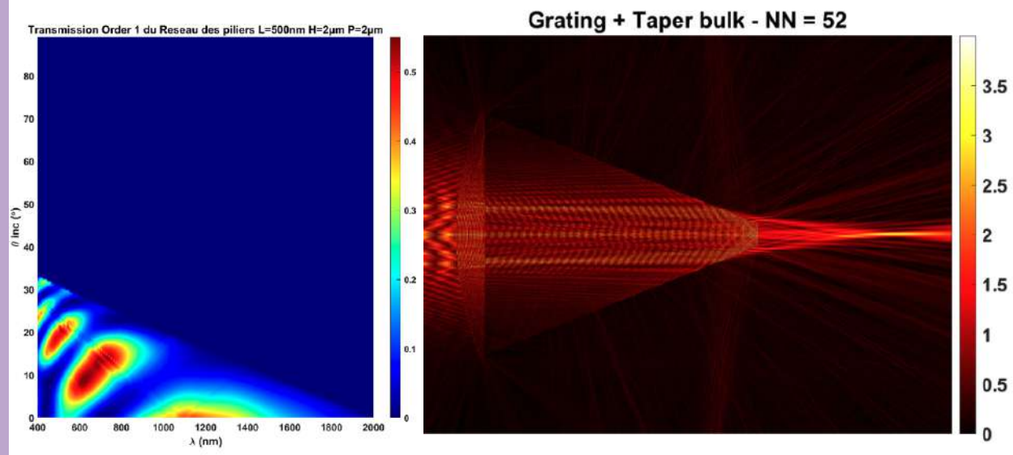


Fig. 1: Example of grating optical simulation results obtained using FMM (left) and FDTD numerical methods (right).

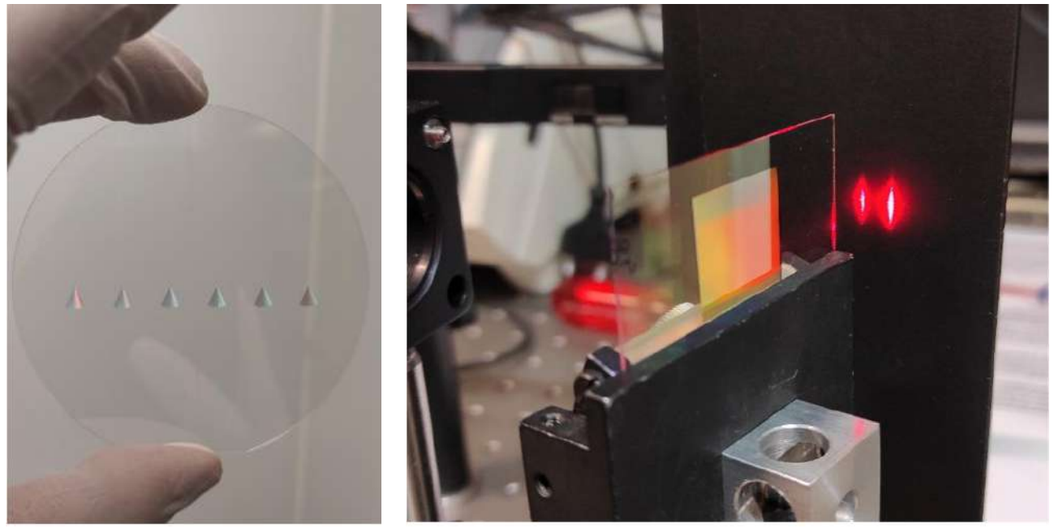
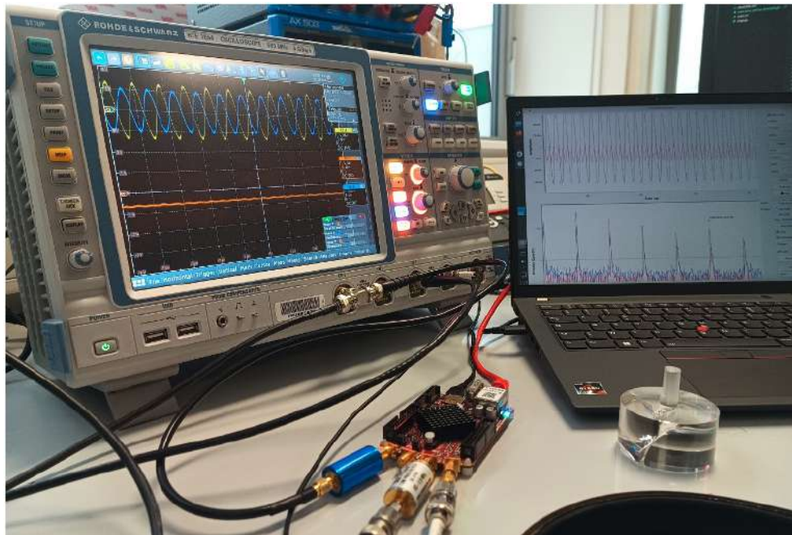


Fig. 2: Focusing grating microfabricated in cleanroom on 3-inch glass wafer (left). Example of grating characterisation using a 632nm HeNe laser in an optical bench (right).

Lock-in Amplifier Built on FPGA and Microprocessor Embedded Device

The use of lock-in amplifiers is widespread in optics and atomic physics experiments due to their ability to extract signal amplitudes and phases in extremely noisy environments. The advent of fast microprocessor devices and Field Programmable Gate Arrays (FPGA) has paved the way for the implementation of digital processing, and today instrumentation technology has largely moved into the digital domain. Based on the Oscillator-IMP ecosystem developed at the FEMTO-ST Institute, we have designed a lock-in amplifier based on an FPGA and microprocessor embedded device. This device operates as a stand-alone device that can be remotely controlled through an Ethernet network connection via a web-based interface and is therefore facility independent. It can also be logged into the embedded operating system via the SSH protocol for direct low-level control.

benoit.dubois@femto-engineering.fr



The first prototype developed on the REDPITAYA board has been tested on the ULISS ultra-stable oscillator, previously developed at the FEMTO-ST Institute and now marketed by FEMTO Engineering.

Seven microprobe X-ray dosimeter for real-time in vivo monitoring of brachytherapy treatments.

Maturation project

Little Invasive Detector of Ionising Radiation

M. A. Suarez, T. Grosjean

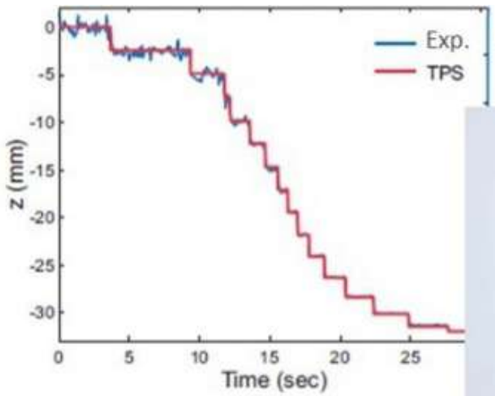
OPTICS

This project was carried out in parallel with the ANR project NANOPTiX (Ultracompact fibre X-ray detectors based on scintillators coupled to nano-optical antennas), coordinated by the FEMTO-ST Institute. The objective was to develop X-ray detectors integrated at the end of optical fibres the size of a human hair to monitor treatment delivery in external beam radiotherapy and brachytherapy. Miniaturisation is achieved by implementing the concept of a nano-optical antenna at the tip of the optical fibre. The resulting fibre probes are low cost and compatible with mass production. In this context, a patent has been filed and a maturation programme with SATT SAYENS (Société d'Accélération du Transfert de Technologie) has been launched during the ANR project. At the end of this programme, fully biocompatible seven-probe detectors have been developed at the end of compact fibre bundles for monitoring treatment delivery in high dose rate brachytherapy. Such multi-probe devices are narrow enough to fit inside the needles used in prostate brachytherapy. They allow accurate monitoring of treatment delivery directly to the tumour(s), but also to the surrounding healthy tissue. More broadly, our fibre probe devices address needs in cancer treatment that are currently unmet in the marketplace.

M. Gonod et al. , Med. Phys. 50, 11, 7192-7202 (2023). https://doi.org/10.1002/mp.16745

T. Grosjean. Little invasive detector of ionising radiation, Patnets FR3089306A1 (06/05/2020), WO2020108827A1 (04/06/2020), CN113167915A (23/07/2021), EP3887866A1 (06/10/21), JP2022510337A (26/01/22), US11520059B2 (06/12/2022)

thierry.grosjean@univ-fcomte.fr



The biocompatible dosimeter is 0.32mm.

An encapsulated detector is available for clinical use.

PTD DGA

EDAM2: Towards a French Industrial Atomic Micro-clock with Enhanced Performance

N. Passilly, R. Boudot

MN2S, TIME & FREQUENCY

Partners: Tronics (TDK), Syrlinks (Safran)

The EDAM2 project is supported by the DGA (Direction Générale de l'Armement) and confirms the continuation of a fruitful collaboration initiated in 2014 between Tronics (TDK), Syrlinks (Safran) and FEMTO-ST. Launched in August 2023, the EDAM2 project aims to improve the performance of the French industrial chip-scale atomic clock, in particular by reducing power consumption and improving long-term stability. This clock will have several applications, such as underwater sensing, GNSS-based navigation systems or secure and jam-resistant communications.

Total funding: 10 M€

FEMTO-ST funding: 529 k€

Illustration of the industrial chip-scale atomic clock (MMAC-10) proposed by Syrlinks.

https://www.syrlinks.com/en/time-frequency/mems-micro-atomic-clock-mmac/mems-micro-atomic-clock-mmac

nicolas.passilly@femto-st.fr

rodolphe.boudot@femto-st.fr

Patent

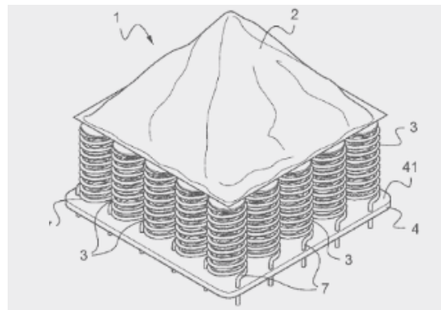
Shape-Memory Programmable Device

J. Gaber, A. A. Chafik

DISC

Partner: Univ. Hassan II (Maroc)

This is an international patent for programmable shape memory technology. This device is based on a deformable layer and mechanical actuators made of individual shape memory alloys (AMFIs). These AMFIs, distributed on a support surface, make it possible to individually and independently generate localized deformations of the deformable layer in response to a stimulus. Thus, the technology can modify, in a controlled manner, the three-dimensional shape of the device.



Shape-memory programmable device.

J. Gaber, A.A Chafik, M. Ennaji, S. Tayane
Patent: FR2111153A, EP2022079098W, WO2023066999A1

jaafar.gaber@utbm.fr

ASTRID Maturation

DApIA Project

R. Couturier, F. Bouquet, B. Legeard, M. Salomon, F. Ambert

DISC

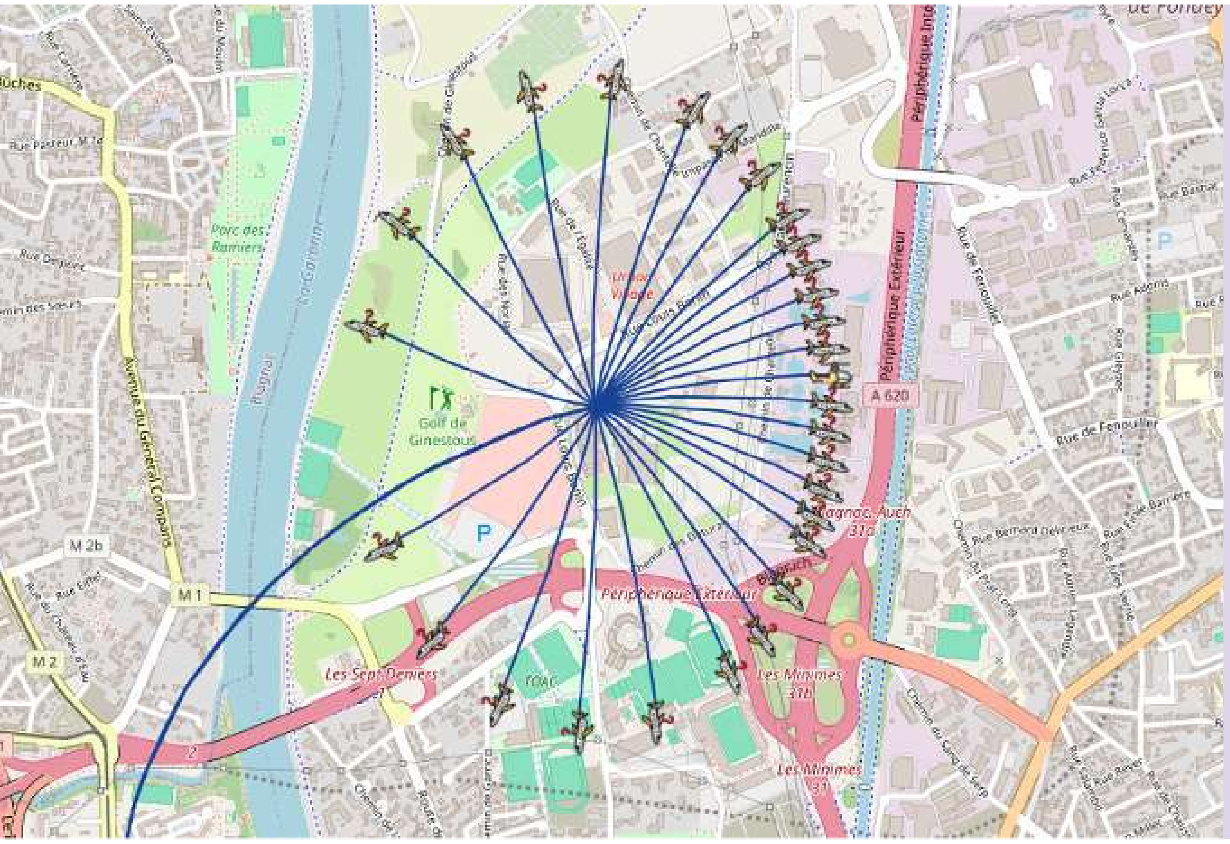
The DApIA project is concerned with the detection of false ADS-B data injection attacks in civil and military air traffic control.

It is an ASTRID maturation ANR project based on the results of the ASTRID project GeLeaD - Generate, Learn and Detect. Based on our previous results, the DApIA project aims to mature and extend the results obtained in three main areas: (1) taking into account any trajectory for any flying object, and in particular low-altitude traffic such as drones and helicopters; (2) improving the performance and coverage of attack scenarios of ML (Machine Learning) detection models at both supervised and unsupervised levels, and implementing them in real time to allow their integration in air traffic control environments; (3) providing a modularisation of the detection chain to facilitate its adaptation to different civil and military contexts and its evolution as the threat evolves.

As a result, the ASTRID Maturation DApIA project will provide false data injection attack detection capabilities adapted to both low and high altitude air traffic contexts. It will provide a set of components ranging from data acquisition from real or simulated sources, preparation for supervised and unsupervised learning, and wide-area detection of changes in surveillance data.

https://github.com/DApIA-Project

raphael.couturier@univ-fcomte.fr



An example of a flood attack (the normal flight is that of the helicopter). The DAPIA AI model is able to detect it.

Verso - the Choice of La Poste for the Optimisation of the Last Mile

The Service, Letters and Parcels Division of the French Post Office has chosen Verso to optimise its routes and it is now an integral part of La Poste's infrastructure. Verso, start-up of FEMTO-ST, has been recognised for their expertise in route optimisation, both for the quality of our solutions and the speed of our algorithmic calculations. La Poste is known for its high level of expertise in service routing, which is at the heart of its operations. However, the first period of lock-down during the pandemic in France saw an unprecedented increase in demand for services for which its standard logistics tools were not equipped. Effective solutions had to be found quickly to meet the needs of those working in the field. Verso was able to do just that. As La Poste continued to test the Verso-powered infrastructure, its adaptability quickly became apparent. The speed at which the algorithmic calculations were performed allowed a significant number of large-scale problems to be solved simultaneously, allaying fears that the infrastructure would prove impossible to scale. Encouraged by the success of these practical tests, in 2021 La Poste began developing Optimiss, a management tool focused on specific aspects of its operations - urban logistics, pick-ups and drop-offs, meal deliveries, etc. - which uses Verso's algorithms to allocate and order tasks based on available resources and the totality of different constraints.

Optimiss has been able to determine efficient delivery routes that take into account specific needs for more than 2,300 sites (10,000 vehicles that carry out around 170,000 services every day).

by J. Coupey

https://www.lesechos.fr/pme-regions/bourgogne-franche-comte/les-algorithmes-de-verso-jeune-pousse-de-besancon-optimisent-les-tournees-de-la-poste-1978256

https://blog.verso-optim.com/fr/

https://verso-optim.com

Parcel delivery using an electric cargo bike.

Photo credit: La Poste

The FRANCE RELANCE plan has been launched in 2020 by the French government to fight unemployment and to secure jobs in France during/after the COVID-19 pandemics. Within this framework, the Applied Mechanics Department has initiated 4 collaborative projects with industry.

MAHYTEC

APPLIED MECHANICS

Project: ALLEGRO

F. Thiébaud, D. Perreux

The project is a 24 month collaborative project. The project is dedicated to understand the way of mass reduction of hydrogen tanks type IV for hydrogen aircraft application. The main part of the work has been made to investigate the mechanical behaviour at low temperature of polymer and high performance carbon composite. The main objective of this work is to reduce the safety factor of the tank design and the hydrogen density by reducing the temperature and increasing the pressure.

D.Perreux, The role of composites in the energy transition: the example of hydrogen energy storage, Invited paper, ISAIME 2023, Bandung, Indonesia.

Tensile test at ultra low temperature of polymer used in Type IV hydrogen tank.

Prototype of a gas storage tank manufactured from flax fibres using filament winding process.

Project: MATRIOSCA

F. Thiébaud, V. Placet, B. Sala

The aim of this collaborative project between MaHyTec and the Department of Applied Mechanics at FEMTO-ST is to evaluate the potential of plant fibres for the manufacture of structural components for gas tanks and to produce initial prototypes that meet regulatory requirements. The current generation of gas tanks is reinforced with industrial fibres, typically carbon or glass, which have a significant carbon footprint in their manufacturing and recycling processes. The use of natural fibres, such as flax and hemp, offers an interesting alternative. However, their integration into structural applications is challenging due to their variable mechanical properties and lower performance compared to carbon fibres.

www.mahytec.com
dominique.perreux@univ-fcomte.fr
vincent.placet@univ-fcomte.fr

SEGULA Technologies

APPLIED MECHANICS, TIME & FREQUENCY

Project: BIOMECAT01

E. Jacquet, J. Chambert, J.-M. Friedt, P. Sandoz,
S. Scarbillet, V. Tissot, P. Roux

The project (2 years) studied 3D printing to design and realise an ultra-light (45g) handheld instantaneous human skin extensometer made of biocompatible polymer. The instrument has its embedded electronics for signal detection, conditioning and USB transmission. The addressed force range is 10mN - 2N for in-plane skin stretching, but the device is also designed to detect the axial force applied to the skin to provide accurate test conditions. The shape of the device and its sensitive structures have therefore been optimised to allow multiplexing and demultiplexing of axial versus tangential forces. The mechanical-electrical transduction is based on strain gauges connected to an embedded low-noise amplification unit.

https://www.segulatechnologies.com/fr/
patrick.sandoz@femto-st.fr

Cisteo MEDICAL

APPLIED MECHANICS, FEMTO Engineering

Project: TROUSER STENT

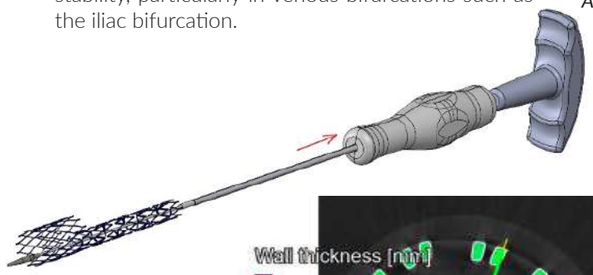
M. Fontaine, P. Stemflé, F. Richard, Y. Gaillard, A. Lejeune, P. Malécot, A. Sallami

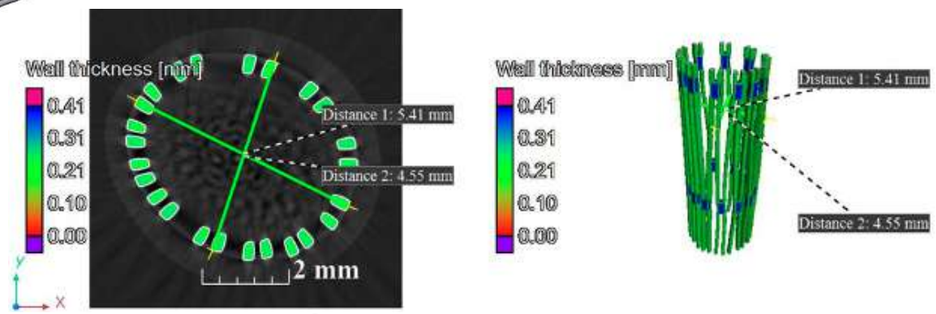
This collaborative project "New generation of stents for venous stenosis" between Cisteo MEDICAL and the Department of Applied Mechanics at FEMTO-ST aims to investigate the impact of both geometry and manufacturing processes on the behaviour of Nitinol stents used in the treatment of venous stenosis. Cisteo MEDICAL's aim is to develop a new generation of self-expanding Nitinol stents with different diameters and geometries within the same stent. This innovation is designed to ensure optimal stability, particularly in venous bifurcations such as the iliac bifurcation.

The integration of numerous experimental and simulation results has facilitated the establishment of a comprehensive numerical framework. This framework supports the design of these stents by managing their thermomechanical properties, with a particular focus on superelasticity. It also addresses their ability to be seamlessly introduced into delivery devices, then into the veins, and finally to remain securely in place. Scientifically, the research has revealed the intricate relationship between stent geometry, manufacturing processes (including laser machining, deburring, forming and heat treatment) and the nature of the contact between the stent when compressed in the PTFE delivery system and when deployed in the vein.

A. Sallami, et al., Tribology International.
A. Sallami et al., ECCOMAS Proceedia SMART, 1423-1434 (2023). http://doi.org/10.7712/150123.9914.444643

www.cisteomedical.com
michael.fontaine@ens2m.fr





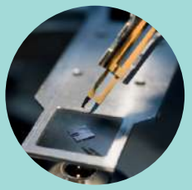
X-ray tomography analysis of a trouser stent inside the ancillary devices.

FEMTO-ST INSTITUTE FOSTERS RESEARCH AND INNOVATION TO ADDRESS THE SOCIETAL CHALLENGES

SCIENCE & SOCIETY

HEALTH
AND WELL-BEING

- Therapy
- Diagnosis, screening and biological qualification
- Ethics and acceptability



CLEAN, SAFE &
EFFICIENT ENERGY

- Hydrogen energy
- Energy harvesting
- Energy efficiency of systems

ENVIRONMENT

- Environmental sensors
- Geodesy
- Water and air treatment
- Vibration and noise protection
- Preservation of resources

INDUSTRY OF THE FUTURE

- New materials and processing
- Sensors and actuators
- Factory 4.0

INTELLIGENT SYSTEMS

- Artificial intelligence: distributed systems, diagnosis and prognosis
- Smart objects & complex systems
- Ethics

COMMUNICATION
AND INFORMATION

- Ultra-localized optics
- Quantum technologies
- Telecommunication systems and materials

DEFENCE - SECURITY

- Network and software security
- Intelligent systems for defence

60 years of a Laboratory of Optics at the University of Franche-Comté

J. Dudley, L. Froehly, M. Jacquot

OPTICS/ UFC

The year 2023 saw the 600th anniversary of the University of Franche-Comté, which was established in 1423 as the tenth university in France. The year 2023 also represents 60 years since the founding of the first research laboratory in optics (as distinct from general physics), and to celebrate this double anniversary, the Department of Optics carried out a series of historically-oriented actions to preserve and promote its rich heritage. These included a detailed search of archival material to understand the development of optics in Franche-Comté, and this yielded previously-unknown links with leading figures of French science dating back to 1845. The department was also able to locate and restore a collection of over 200 historical scientific instruments (many dating to the 1800s), preserve publications and other documents dating from the 1920s, and record oral history interviews with retired staff members. Significantly, the collection of optics instruments has now been included in a national registry of scientific heritage (PATSTEC). These various actions were presented at a morning conference on the International Day of Light on May 16, opened by the President of the University, and attended by a large number of present and former staff.

J. Magnin, J. Querenet, L. Froehly, J. Salvi, M. Jacquot, A. Levenson, J. M. Dudley. Teaching through history: the preservation of modern French scientific heritage in optics. Seventeenth Conference on Education and Training in Optics and Photonics: E127230F (2023). https://doi.org/10.1117/12.2666612

A. Levenson and J. M. Dudley. Saving the intangible heritage of French Optics. Photoniques 122, 25-29 (2023).

https://projects.femto-st.fr/patrimoine-scientifique

john.dudley@femto-st.fr

UNIVERSITÉ DE FRANCHE-COMTÉ
600 ans d'histoire

OPTICS

Some items from our scientific instrument collection displayed in the FEMTO-ST building

Soliton representation on the cover of the Optica Flagship Journal Optics & Photonics News in May 2023

Fifty Years of Solitons in Optical Fibre

J. Dudley

OPTICS

The study of temporal solitons has revolutionized fiber optics, yielded new classes of ultrafast laser and opened multiple interdisciplinary applications. Although known in hydrodynamics since the 19th century, the prediction that solitons could be observed in optical fibre was made only in 1973, and to celebrate this fiftieth anniversary, a number of different actions have taken place within the optics community worldwide. Soliton physics has been a key research theme within the department of optics of FEMTO-ST for more than 25 years, essential to work studying guided-wave nonlinear propagation, supercontinuum generation, ultrafast fibre lasers, and the dynamics of microresonator frequency combs. In collaboration with researchers from the University of Burgundy (ICB CNRS UMR 6303), Tampere University (Finland) and Imperial College London, John Dudley from the optics department was lead author of a general review on the subject for the flagship journal Optics & Photonics News, published by Optica. This review featured on the cover of the journal! He also delivered an invited tutorial for Masters and PhD students at the European Optical Society Annual Meeting which was held in Dijon during 2023. This work has aimed to highlight how soliton physics is central across multiple areas of science.

J.J. M. Dudley, 50 years of solitons: fundamentals to applications European Optical Society Annual Meeting, 11-15 September (2023)

M Dudley, C. Finot, G. Genty, J. R. Taylor. Fifty Years of Fiber Solitons. Optics and Photonics News 34(5) 26-33 (2023)

https://www.optica-opn.org/home/articles/volume_34/may_2023

john.dudley@univ-fcomte.fr

Étonnante physique, edited by Séverine Martrenchard

Chapter ‘Puces photoniques 3D bio-inspirées pour l’intelligence artificielle’ in ‘Étonnante Physique’

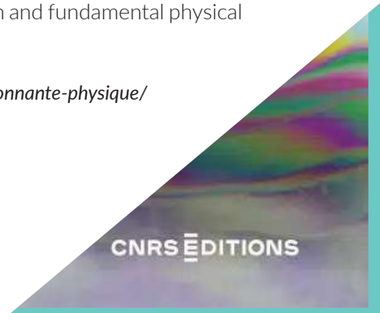
D. Brunner

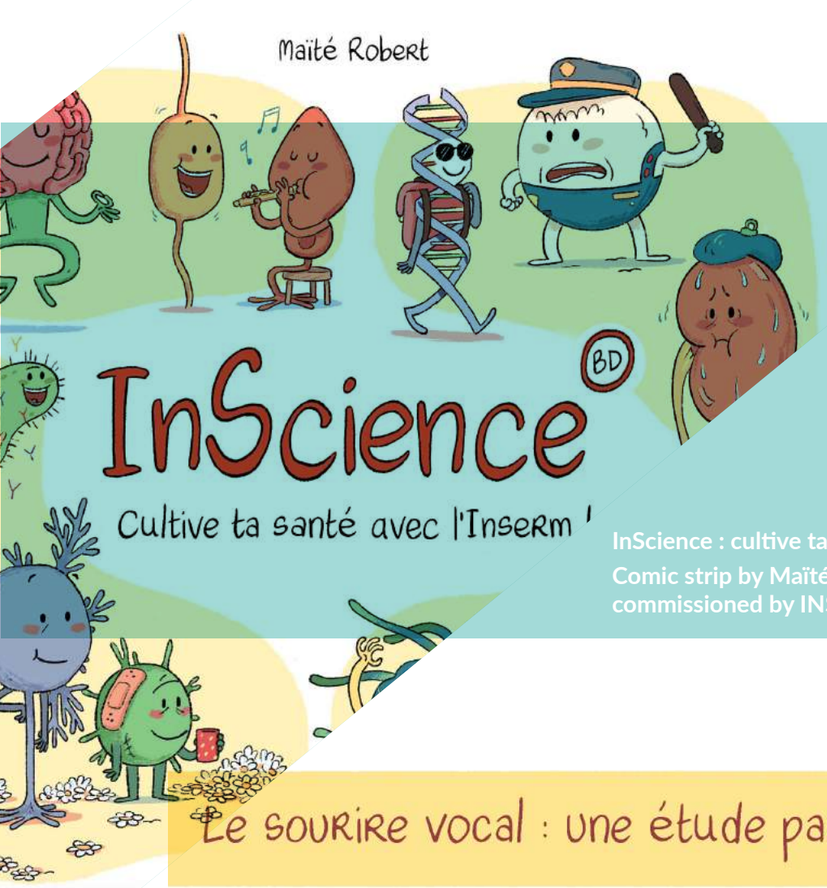
OPTICS

Physics as a discipline explores laws of nature describing the vast range of natural phenomena spanning such wide ranges as for example the immensity of clusters of galaxies to the infinite smallness of elementary particles. The book Étonnante Physique, aimed at the general public, brings together 70 contributions from physicists who have recently been awarded a CNRS medal for the originality and importance of their work. In there, Daniel BRUNNER described his recent work establishing a novel fabrication concept for the integration of photonic circuits in 3D. This extension of our current technology from two to three dimensional circuits is a fundamental requirement to make parallel and high performance integration of neural network hardware scalable. The chapter describes the current state of the art and highlights the fundamental advantages coming from the synergy between 3D integration and fundamental physical properties of optics.

https://www.cnrseditions.fr/catalogue/physique-et-astrophysique/etonnante-physique/

daniel.brunner@femto-st.fr





InScience : cultive ta santé avec l'Inserm !
Comic strip by Maïté Robert
commissioned by INSERM (2023)

Le sourire vocal : une étude pas si bÊÊÊÊÊte !

Marie Gomot est neurophysiologiste, psychologue et chercheuse Inserm au sein du laboratoire Imagerie & cerveau à Tours.

Jean-Julien Aucouturier est ingénieur en traitement du signal, docteur en informatique et chercheur en neurosciences cognitives au CNRS. Il travaille au sein du laboratoire Franche-Comté Électronique mécanique thermique et optique - science et technologies à Besançon.

Ensemble, dans le cadre de leur projet de recherche collaborative ANR SEPIA, ils étudient les réactions sensorielles et émotionnelles au sourire vocal, notamment chez les personnes présentant un trouble du spectre de l'autisme.

Chèèèèèèèvre !!!
On pose ça là, vous comprendrez. Bonne lecture !

Comics "Le sourire vocale : une étude pas si bEEEEEte !"

J.J. Aucouturier

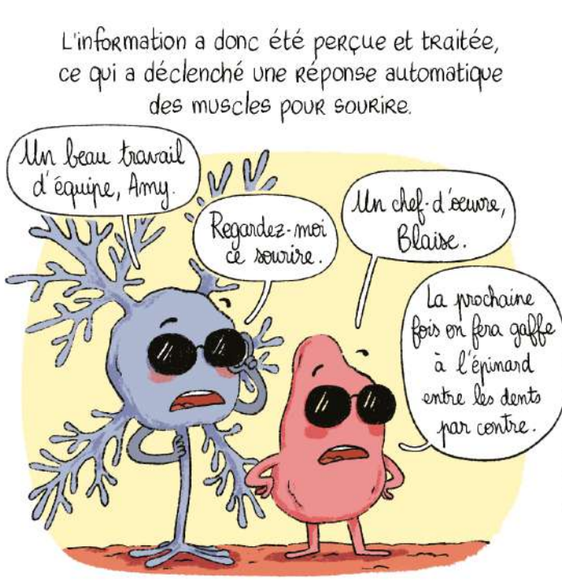
AS2M

The French national ANR SEPIA project (JJ Aucouturier - AS2M & Marie Gomot - iBrain, Tours) is one of 10 biomedical projects selected by INSERM for the comic strip. The comic strip InScience: Cultivate your health with Inserm! takes us to the heart of biomedical research, with an educational and humorous approach. This scientific communication initiative has already been awarded the "Coup de cœur éditorial 2023" by Arces, the Association of Higher Education Communication Managers.

https://www.inserm.fr/culture-scientifique/bande-dessinee-inscience-cultive-ta-sante-avec-linserm/

jean.aucouturier@femto-st.fr

* l'amygdale est une structure qui traite les informations émotionnelles et déclenche les réactions comportementales



ARTIST RESIDENCY IN A RESEARCH LABORATORY

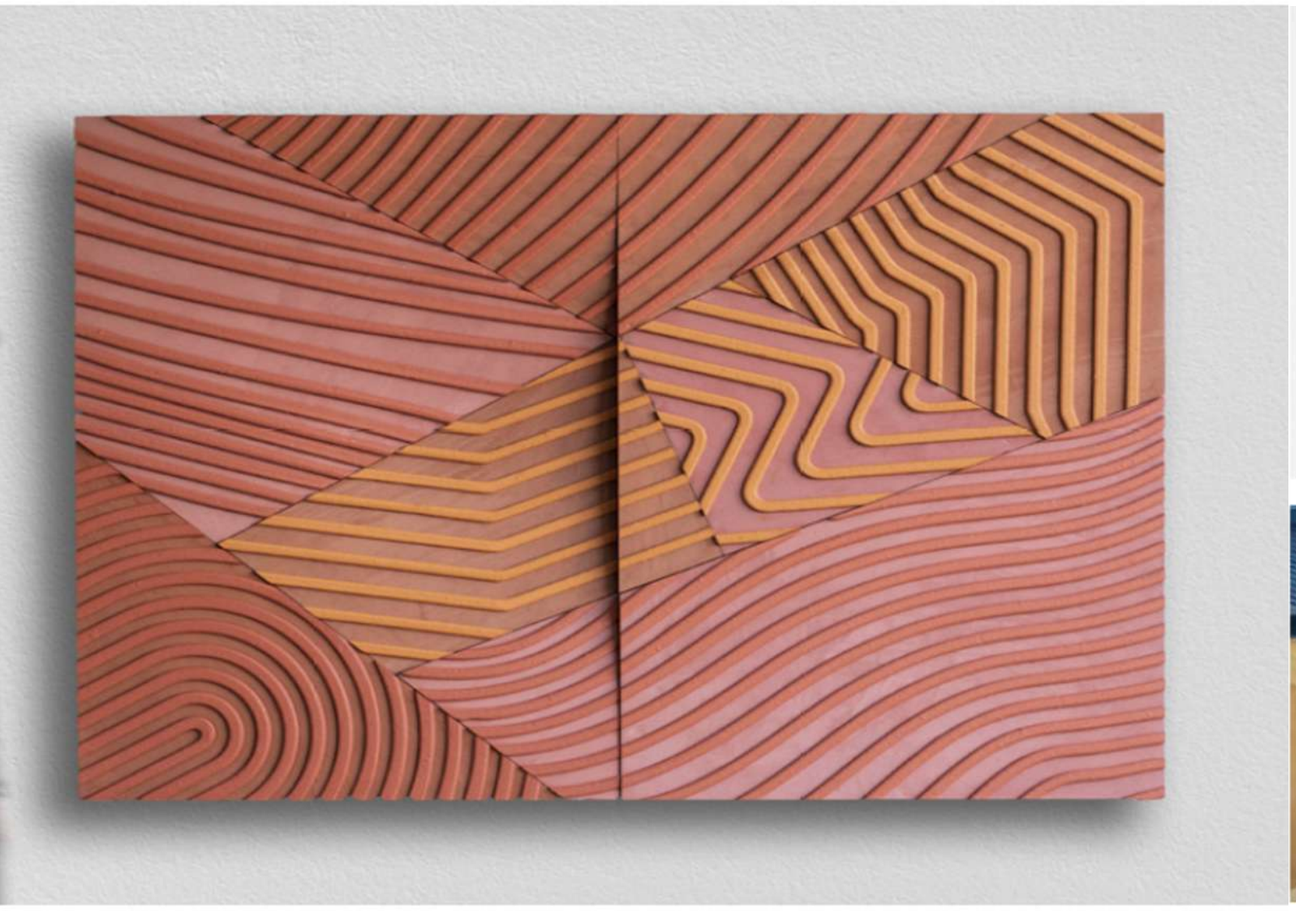
Artist/Designer Quentin Didierjean

Academic year 2023-2024 (ENERGY)

"As a designer, designing an object and defining how it interacts with its users means that, whether you like it or not, you're passing on a point of view about society. That's why I see residencies as a time to step back from that point of view and explore other paradigms."

The exhibition will be accompanied by a printed book, a way of leaving a trace and putting these projections to the test of time.

UFC, in partnership with DRAC Bourgogne Franche-Comté and Région BFC



"Concevoir des objets désirables et durables."

"Explorer les futurs souhaitables"

2023 OUTREACH ACTIVITIES

VIDEO OF THE ROUND TABLE "WILL HYDROGEN TECHNOLOGIES SAVE THE WORLD? "

FESTIVAL INOUIH 2, TECHN'HOM, "Transformation of an industrial region", Belfort

HYCKATHLON, Gardens of the Belfort Prefecture

SCIENTIFIC GAME JAM, Pavillon des Sciences, Montbéliard

FEMTO-ST TEAM "FLEMME TÔT RUN'
Participation in relay marathon EKIDEN 2023, Grandes Heures Nature Besançon, UTMJ 2023....

FORUM HYDROGEN BUSINESS FOR CLIMATE, J.-L. Etienne interviewed by CMI Hydogène-Energie student

ESCAPE GAME DEDICATED TO PARITY "CARNET D'ANNA" UNESCO, Besançon

FÊTE DE LA SCIENCE, Besançon & Belfort

Thanks to:

P.-A. Lacour, F. Courvoisier, G. Fanjoux, L. Froehly, M. Suarez, A. Bolopion, A. Lefevre, S. Jemei, V. Lepiller, P. Desevaux, M.-C. Pera,K. Deschinkel, K. Mazouzi, Y.A. Oumeziane, D. Bouquain, L. Carpentier, G. Layes, S. Basnet, S. Rahman, M. Fernandez, N. Kroichvili, R. Roche, B. Rey, O. Dembinski, A. Niechajowicz, N. Winckel, J. Bourgeois, N. Yousfi Steiner, A. Figarol, A. Rabbe, N. Brosseau-Habert, L. Froehly, V. Humblot, S. Midrouet, M. Prudhomme, G. Vilar Soler, T. Zwingelstein,M. Ouhabaz, M. Delehaye, G. Fawaz, A. Bartasyte et al.

FEMTO-ST

IN FIGURES

772

MEMBERS

INCLUDING
- 248 Professors & Associate Professors
- 35 CNRS Researchers
- 292 PhD Students
- 31 Postdocs
- 71 Engineers/technicians

MORE THAN

100

WORLDWIDE INSTITUTIONAL ACADEMIC PARTNERS

7 RESEARCH DEPARTMENTS

12 START-UPs IN 11 YEARS

325+

SCIENTIFIC ARTICLES IN 2023

1 INNOVATION TRANSFER UNIT (FEMTO ENGINEERING)

1 MICRO-NANO TECHNOLOGY CENTRE (CLEAN ROOM MIMENTO)

10 RESEARCH FACILITIES / INFRASTRUCTURES

38 M€

ANNUAL BUDGET

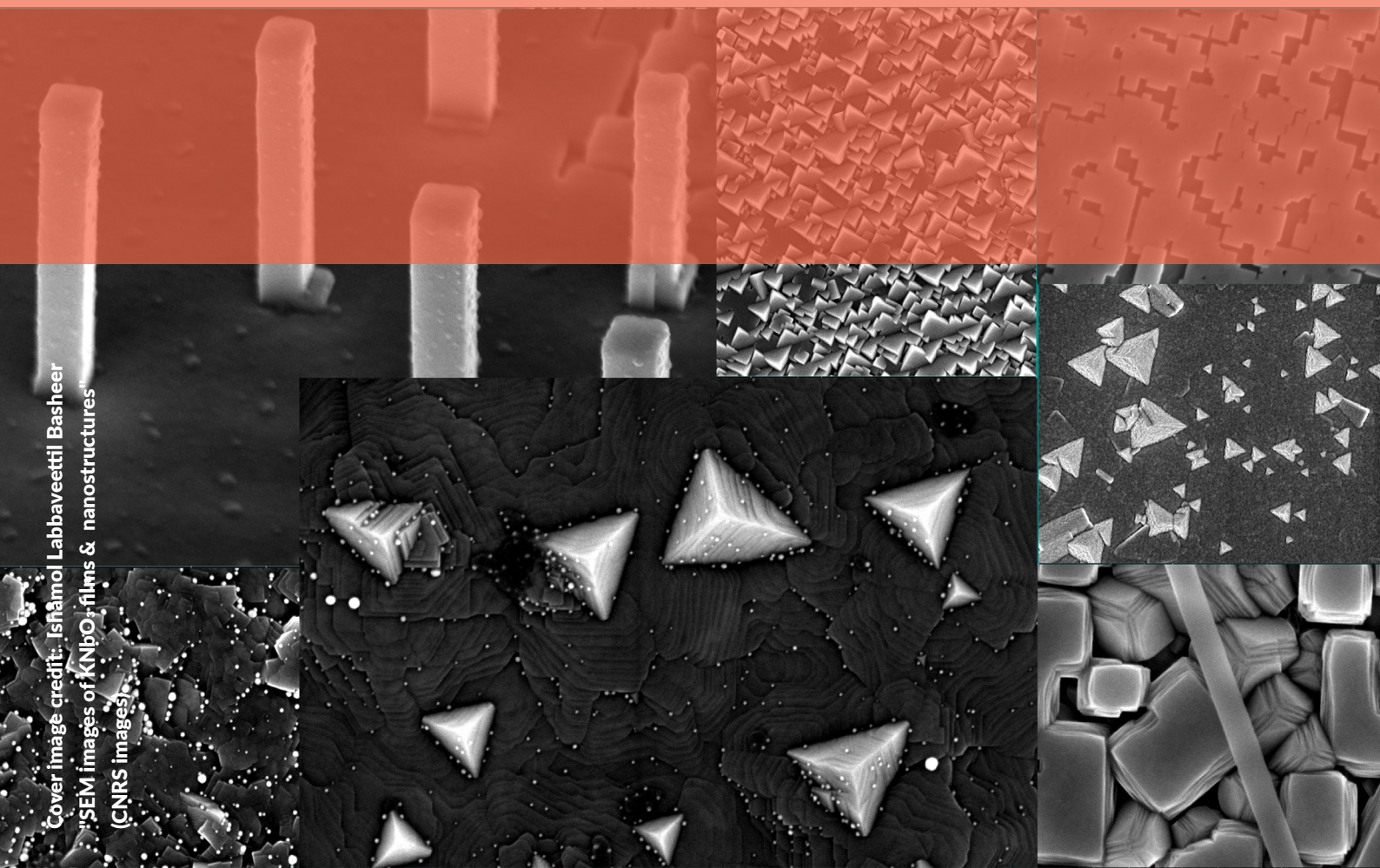
161

RESEARCH CONTRACTS IN 2023

Financially supported by :

Photo credit:
L. Godard / UFC
S. Quaroz / FEMTO-ST
F. Jouffroy / UTBM

FEMTO-ST Institute
15B avenue des Montboucons
F - 25030 BESANÇON cedex - France
Tel.: +33 (0)3 63 08 24 00
www.femto-st.fr



Cover image credit: Ishamol Labbaveettil Basheer
"SEM images of $KNbO_3$ films & nanostructures"
(CNRS images)